POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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Erosion of turbine blading

FASTER THAN SOUND

IF YOU COULD SIT on the end of one of the low pressure blades of a modern high capacity steam turbine when it was in operation and someone exploded a fire cracker behind you, do you realize that it wouldn't scare you in the least? Indeed, you'd never even hear it, for you would be going so fast the sound would never reach you. Such blades in some of the larger turbines travel at the rate of 13.8 miles per minute; considerably faster than the speed of sound in air!

Naturally, when traveling at this speed, anything that may strike the blades, particles of water or solid matter, causes terrific erosion. Even gases; a rotor operating at this speed in air at ordinary pressures would heat to a red heat in a short time because of the friction of the air. A small stream of water directed across the path of the blades, it is said, will wear them through in a matter of minutes.

In practice, of course, these blades travel practically in a vacuum. The steam which keeps them moving travels at speeds only slightly higher, so that the relative speed between blade and steam is small. But even so, if there are impurities in the steam or if water particles are present, the blades are subject to erosion and in practice this constitutes one of the more serious problems of turbine maintenance.

This question of turbine blade erosion forms the subject of discussion of a very interesting N.E.L.A. report and, since this problem is one with which all power plant operators are concerned, we present the substance of this report on page 121. The picture above shows what happens in instances of this kind.

In steam turbines the problem is to keep water away from the blades but in hydraulic turbines, we want to keep the water in contact with the blades as much as possible. Well, at Hoover Dam they will have plenty of water to work with, the whole Colorado River in fact. Work on this stupendous project is proceeding rapidly and the construction of the power plant has now been started. The specifications for the generating units of this large project naturally are interesting and so we present them on page 124.

Another article in this issue to which we wish to direct attention is the one on the Procedure in Design of Forced and Induced Draft Systems in Boilers, by George Daniels. Mr. Daniels, who is mechanical engineer of the Commonwealth and Southern Corp., points out that many haphazard methods still exist in the design and selection of draft equipment and shows how this has often limited the capacity of boiler installations. Experienced engineers to meet this condition frequently make use of a large factor of safety or perhaps a "factor of ignorance," but this results in needless capital investment. So Mr. Daniels outlines the correct procedure which should be followed in cases of this kind and presents formulae and constants so that calculations can be made. It is amazingly simple once you see how it's done.

One thing more, particularly if you are interested in refrigerating condensers. Despite the fact that recent years have seen many developments in condenser design, there has existed a need for still better equipment in this field. For this reason the article on Ammonia Condensers by B. D. Landes on page 130 should be of interest since it describes a condenser which seems to have many unique features, and there is no reason why it should not be exceedingly effective, both as to economy of operation and maintenance.

WITH THE EDITORS

Safe Operation Requires Good Engineering

AS AN ENGINEER goes from plant to plant throughout the country he cannot help but observe the increasing number of makeshift repairs and homemade gadgets that are being used, particularly in power plants serving small industries and located in out-of-the-way places. The impression made on the visitor is that the owner of the plant is trying to get by without paying the necessary price for safe, first-class repair jobs and equipment expertly designed for its particular purpose.

Above everything else, safety is the prime essential of power plant equipment and operation. Too frequently the owner of a plant lacks familiarity with equipment design and repair work sufficient to judge the quality of the work that is being done for him and allows price of equipment and cost of repairs to predominate judgment in his management of the plant. Certainly in these times economy should be practiced to the limit but to go beyond the limit is to gamble with the lives of workmen and passers-by—a risk no plant owner should be permitted to take.

Investigation has revealed that boiler failures during recent months have been on the increase and several disastrous explosions have recently occurred. Such loss of life and property can usually be attributed to ignorance or an unwarranted attempt to save money.

As an example of how an attempt to economize may result in unjustified expense, an incident came to our attention recently. A boiler was found to require a patch. A local boiler repair man who was called in told the owner he could weld on a patch at a cost much cheaper than one could be riveted on. In the end the welding was unsatisfactory and unsafe, the patch had to be remade and the total cost was more than doubled, due to the advice of an incompetent workman.

Power plant equipment, unlike most other industrial machinery during this depression period, has seen almost continuous service, though in few cases has it been loaded to its full capacity. As this equipment ages, deterioration takes place more rapidly and repair bills are bound to increase. Delayed repairs mean increased costs. Under these conditions more frequent and more thorough inspection is advisable, necessary repairs and replacements should be made promptly and the engineer should warn the owner and refuse to operate equipment which he considers dangerous to life and property.

Utility Rates

AGITATION FOR lower rates exists in all sections of the country, most of it coming from a form of petty racketeering only too often masquerading under such impressive names as tax payers leagues; bond holders protective committees, and power customers associations.

In the face of rapidly dropping commodity prices, well established power, gas and telephone rates stand out prominently and form a splendid target for those who prey upon the minds of the unthinking public.

Isolated cases of excessive private company rates have, and probably still do exist, just as successful and well managed municipal plants exist. Taken as a whole, however, public ownership represents technical stagnation while private capital represents the directing force that has during the past few years cut the coal rate per kilowatt hour in half, covered the country with a network of natural gas lines and, through the telephone, literally placed the whole country in your back yard.

Politically or sociologically, public ownership may or may not be desirable depending upon one's creed; technically there can be no question. Private capital has been responsible for the great strides made in utility services and, for the time being at least, it would seem that the country can be served best by a full, complete and growing utility service rather than by making these services a political football with the post office department as a shining example.

To be fair, however, it is well to remember that, when looking at utility prices from the present day level, during the years when commodity prices were soaring upward, utility prices were steadily decreasing. Furthermore an average of ten per cent of the power companies' income goes for taxes and the largest part of their operating cost is for coal which in turn consists largely of freight.

In the District of Columbia, telephone, gas and electric utilities are privately owned; water is operated by a government commission. Decreases in average monthly cost from 1920 to 1932 were, for telephone from $5.50 to $4; for gas from $4.49 to $2.80; for electricity from $3.70 to $2.33. Water cost increased from $5.10 to $10.85.

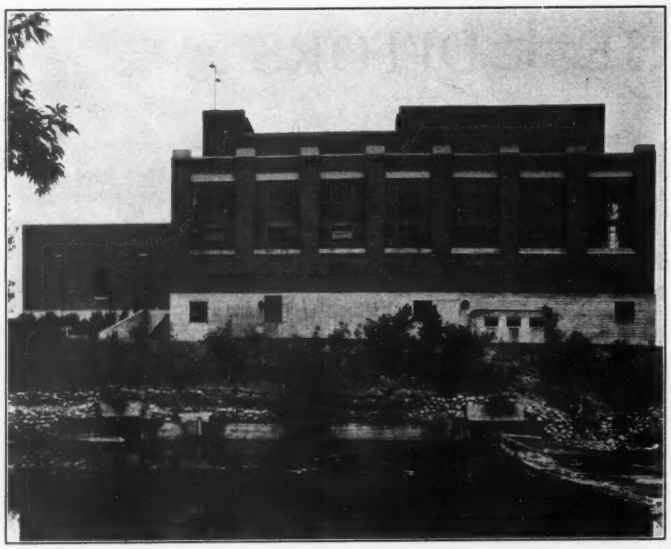
Inasmuch as the water department represents what should be the highest type of government owned management, these figures should be given close study by those investigating municipal ownership schemes at the present time. Successful municipal power systems do exist and local interest in certain cases is perhaps desirable but, in general, the movement can only be condemned by engineers as a step in the direction of technical stagnation.

Warning

BOGUS subscription solicitors are abroad duping engineers and others with various offers. One man using the name of J. M. Adams, offering subscriptions and a free accident insurance policy has recently been working in Missouri and probably other nearby states. Word comes of a man calling himself R. G. Hall who has been active with a similar offer in Florida and probably other southern states.

All authorized agents of POWER PLANT ENGINEERING carry full credentials with the seal of Technical Publishing Co. embossed thereon. Any engineer approached with offers like those mentioned should demand credentials.

Please wire at our expense regarding any such offers. We shall be glad to recompense anybody who is instrumental in apprehending a subscription swindler who is using the name of POWER PLANT ENGINEERING.



KIDDER STATION

Otter Tail Power Co. Adds New Turbine to This North Dakota Station and Extracts Steam to Heat Condensate from Old Machine. Short Fire Method of Chain Grate Operation Radical Development

By G. W. WELSH
Chief Engineer,
Otter Tail Power Co.

KIDDER STATION, 1 mi. north of Wahpeton, N. Dak. on the Red River of the North, was located there, primarily, because of the adequate supply of condensing water available. It is also close to the load center of the system and but ¾ mi. of spur track was necessary for railroad connections. The first section of the plant was built and placed in service during 1927.[1] Part of a second section, comprising an addition to the turbine and operating rooms only, was built in 1931 and the second turbine unit, with its auxiliaries, was installed and placed in service late last year.

The plant has been designed for handling and burning Dakota lignite exclusively and special attention was given to the equipment and method for coal handling and to the boiler room equipment. Lignite is received from the mines, some 200 mi. distant, in open steel gondola dump cars owned by the company. As lignite does not store well in the open and all extra handling was to be avoided, the reserve fuel supply is simply held in the cars on a storage track. From three days to a week's supply is thus held at the plant, depending on the season. There is no demurrage on the privately owned cars and their upkeep is largely covered by what they earn from the railroads in mileage refunds. This system works out very well where the tonnage to be handled is not too great and the source of supply is reasonably close.

[1] See North Dakota Lignite Burned in Kidder Station by Arne Arneson, Power Plant Engineering, p. 1134, Nov. 1, 1928.

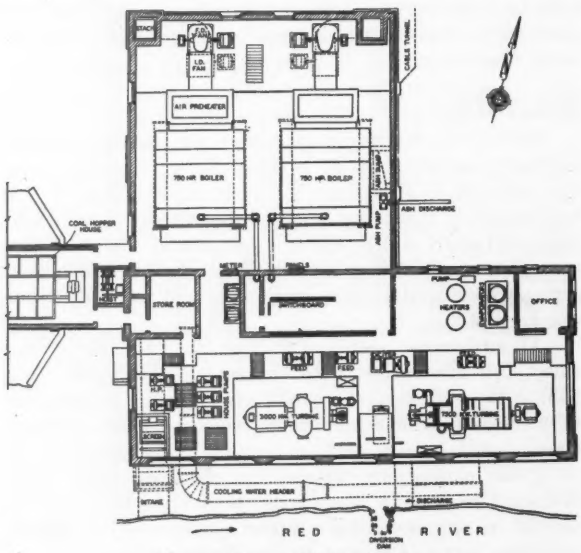


Fig. 1. Plan of Kidder Station

Coal Supply

Coal most used is the so-called slack or screenings running up to about 1¼ in. size. However, there is a shortage of this at certain seasons, so that provision has been made at the plant for handling and crushing the mine run lump up to 8 in. During the unloading, all coal is passed through the crusher for sizing to ¾ in., as this gives best results on the stokers. This lignite will run 6500 to 6800 B.t.u., 38 to 40 per cent moisture, 8 to 10 per cent ash and less than ½ per cent sulphur. Volatile and also fixed carbon average about 28 per cent each, while 25 to 40 per cent will pass a 50 mesh screen.

From the storage track the cars are pulled up a short 4 per cent grade on to the track hopper by a motor operated cable hoist. The empties are dropped back by gravity on to a separate track. The only difficulty with the system occurs in sub-zero winter weather, when some additional help is required. Lignite carries considerable surface moisture and tends to freeze together and stick in cars and hoppers. When this happens extra labor is needed to keep the coal moving. Various mechanical devices have been tried to overcome this difficulty, but these were not entirely satisfactory and the employment of an extra man during the occasional periods of extreme cold has proven the best solution.

The plant building is laid out in three lengthwise divisions with the turbine room on the south, along the river bank, so as to reduce the circulating water piping. The turbine room has three floor levels. The narrow central section of the building is divided into five levels, the lower three corresponding with those of the turbine room.

Third division of the plant is the boiler room, which is arranged in two levels with the lower, or basement, hous-

ing the ash hoppers, sluiceway and sump in a separate compartment.

The two 750 h.p. class T. L. Badenhausen boilers are designed for 300 lb. operating pressure and are equipped with double convection type superheaters to give 175 deg. F. superheat. Copes feed regulators are installed. There are no economizers, the gases leaving the boilers passing directly to the air preheaters, thence to the induced draft fans and out through separate breechings and stacks. Each boiler is set separately with its own preheater and fans; in fact the entire plant can be operated as two separate sections from the boilers to the high bus in the substation outside.

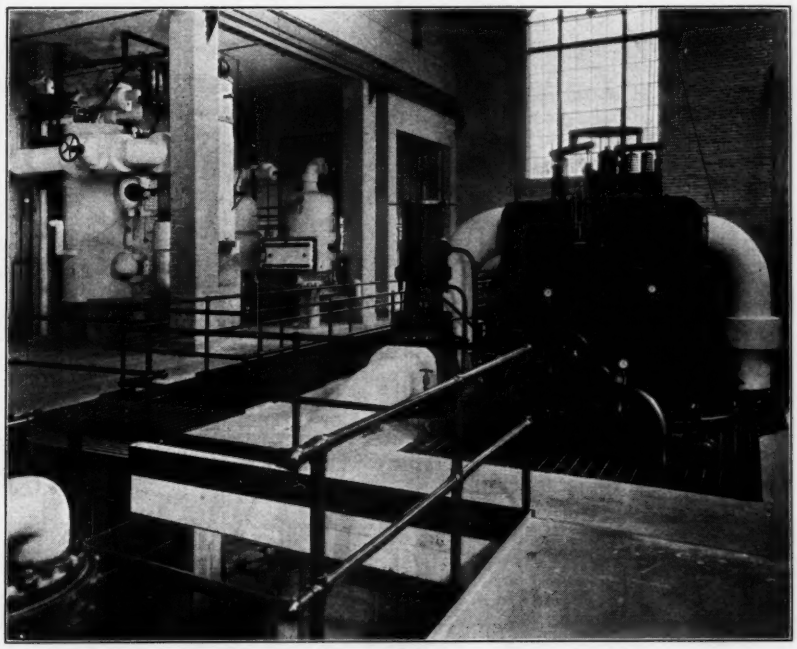


FIG. 2

Turbine Room Looking Toward No. 2 Machine

The open heaters and evaporators are in the background to the left with the extraction heaters directly underneath

Air Supply and Draft

Air preheaters are of the two-pass vertical tube type, each containing 6900 sq. ft. of heating surface. Exhaust gas temperatures range from 250 to 400 deg. F. and exit air from 375 to 400 deg. F. according to the rating. Gases leave the preheaters and pass directly into the double suction induced draft fans located underneath. These fans are down discharge and the breechings are led to the stacks below the main floor. Each fan is direct connected to a 100 hp. variable speed motor.

Forced draft fans, which are mounted on the gallery behind the preheaters, discharge directly into these at the bottom, the hot air passing off the opposite side through two down comer ducts per unit which lead into main air ducts just under the boiler room floor. Each fan is direct connected to a 50 hp. variable speed motor.

Fan speeds are hand controlled from the front of each boiler. Combustion is under control of a Hagan master control unit which actuates the boiler damper and a forced-draft air-damper on each boiler to maintain balanced draft in the furnace. Metering equipment for each boiler is mounted on a flush front steel panel Republic set in the firing aisle partition wall.

Soot blowers are located at six points throughout the boiler. These are double element units, each operated from the corresponding side of the boiler. On account of the width of the boilers it seemed advisable to use short units per position rather than a single long unit extending across the entire setting. The boiler foundations and supports are of somewhat unusual design, the main foundation under each unit being of heavily reinforced concrete and extending several feet below the basement floor. Each foundation block is hollow, forming a reservoir of several thousand gallons capacity for storage of condensate. From this foundation there are two massive reinforced concrete columns carried up on each side which support a heavy steel box-girder of special design. These run lengthwise, one under each side of the boiler, with the top plate at main floor level.

These two girders carry the main boiler columns, which in turn support the entire boiler, stoker and setting; they also serve as ducts to convey the preheated air supply from the main air duct in the rear along each side of the boiler and distribute it to the stoker air zones. Nozzle connections lead from the top of the duct to each stoker air box. The individual zone dampers are located in these nozzles and all connections are kept inside of the outer face of the setting, so that there are no unsightly projections and considerable aisle space and basement space are saved. The rear ends of the girders are anchored solidly to the rear piers, but the front ends are supported on the front piers in roller guides, to permit longitudinal expansion with the considerable temperature changes to which the girders are subjected. This method of support has proven entirely satisfactory and there has been no cracking of settings nor trouble at any point.

Under each boiler there are two 8 by 16 ft. Harrington traveling grate stokers, set side by side and separated by a 12 in. partition wall, which is carried up through the furnace throat. Each stoker has its individual hopper and drive, consisting of a constant speed motor and Reeves variable speed transmission. Combustion air is supplied through six zones on each stoker, each zone being equipped with an individual damper, which is hand-operated from the front of the boiler. Air supply to

either stoker is independent of the other unit. This stoker arrangement is, perhaps, somewhat unusual, but was considered necessary on account of the furnace width of 17 ft., which would have required an excessively wide single unit. Experience has shown that it is difficult to get satisfactory ignition and air distribution with lignite when the stoker exceeds a certain limiting width. The double stoker has worked out well and permits excellent control of the fire. Trials have shown that the center wall has considerable influence in maintaining an even distribution of radiant heat to the fuel bed.

The arch design is also worthy of mention, although it is not new. The combination of the long flat front arch and a short rear arch, with a narrow furnace throat between, has been used in a large number of settings for Western lignite with uniformly good results. The effect of the design is to concentrate radiant heat at the front of the furnace to promote ignition, while providing a zone under the front arch for distillation and burning of volatiles. The throat restriction causes considerable turbulence and a better mixing of the gases at a point of active combustion.

Short Fire Method

Particularly good results are obtained with this design when burning by the older "long fire" method, where the fuel gradually moves back on the stoker and is burned out on the grates undisturbed. With the newly developed "short fire" method,[2] where the fuel is blown from the grate and burned in suspension, some modification of arch design is indicated, particularly for continuous ratings above 300 per cent. Much higher furnace temperatures are attained with this method and the fluxing and erosion of refractories becomes sufficiently serious to require the use of water walls or other means of refractory cooling.

With the "long fire," and with the "short fire" at moderate ratings, there is practically no furnace maintenance. No difficulties have been encountered with the stokers due to high air preheat temperatures and the average life of the grate clips is 4 to 5 yr. with either method of firing.

Cooling water for the plant is taken in at the west end of the building through an intake tunnel under the basement floor. Trash racks and a traveling screen remove the bulk of the floating material, of which there are large quantities at some seasons of the year. In addition a 16 in. single strainer is installed in the suction line of each pump. There is a battery of four circulating pumps located in the basement, adjacent to the intake, each of 4000 g.p.m. capacity. Two are motor driven, one turbine driven and one equipped with dual drive. As all units discharge into a common header, from which the condenser supply lines are taken off, the four pumps may be operated in any desired combination. One pump will serve the No. 1 condenser and two are required for the No. 2 unit at full load.

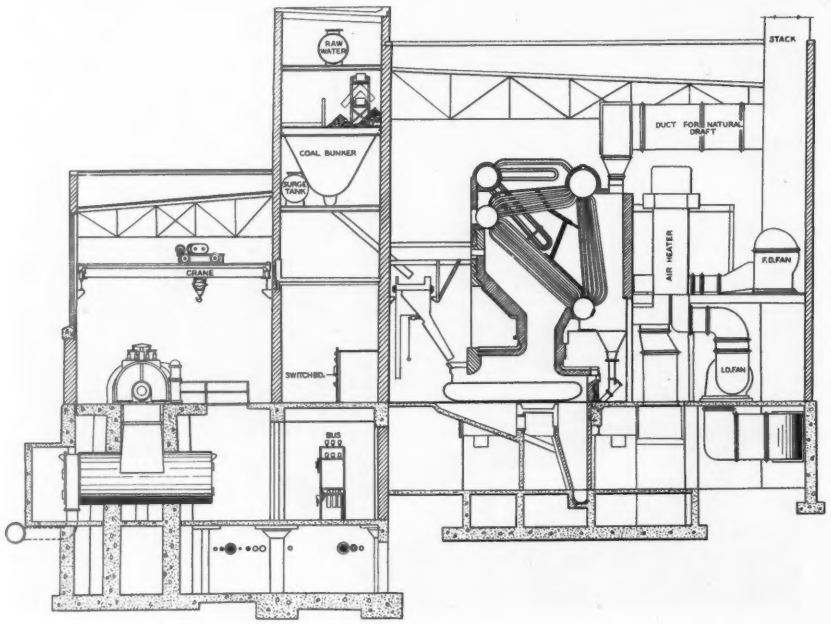


FIG. 3

The Building Is in Three Separate Sections

In the center of the building there is a raised section above the fifth level which incloses raw water gravity tanks

Boiler feed service is handled by one or more of the three multistage turbine-driven feed pumps on the main floor of the turbine room. All are rated for 800 ft. head at 3500 r.p.m., the two older units having each a capacity of 150 g.p.m. while the new unit is 250 g.p.m. All are equipped with excess pressure control.

Boiler make up is supplied from either of two double effect S & K evaporator units. Steam at full boiler pressure is supplied to the first effect coils under control of a governor valve which is actuated by the second effect vapor pressure. The second effect vapor, being condensed in a closed heater by the feed water going to the boilers, causes the evaporator output to be quite closely proportioned to the boiler load. Raw feed water is first passed through a small open heater, where the temperature is raised to 210 deg. F. by exhaust steam, thence it flows to a small motor driven centrifugal feed pump which discharges to the evaporator shells through the control equipment. For each evaporator this consists of a differential pressure valve followed by the main feed valve, which is equipped with thermostatic control similar to a boiler feed control.

[2] Details of this method of firing wil be given in an article by Mr. Welsh to be printed in the next issue.

The condensate from the main condensers passes directly to the condensate pumps, which discharge through the evactor condensers to the elevated surge tanks in the bunker room. Overflows are piped from here to the condensate storage reservoirs in the boiler foundations, from these the water is drawn off and returned to the surge tanks by one or more of the house pumps. From the surge tanks the main flow of condensate goes by gravity to the open heaters on the floor below. There are two of these heaters, which are deaerating type, connected together in parallel and supplied with exhaust steam from the auxiliaries.

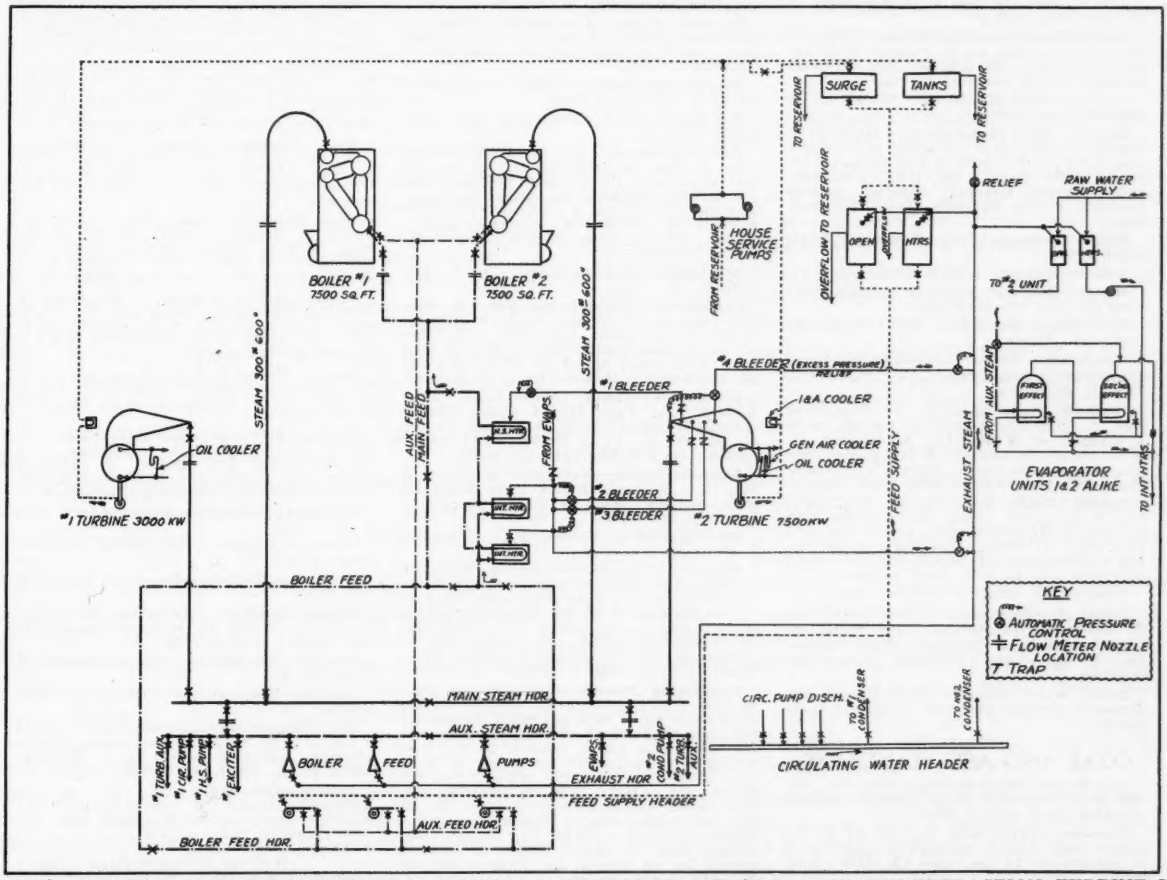


FIG. 4. FLOW DIAGRAM OF THE STATION SHOWING HOW CONDENSATE FROM THE NON-EXTRACTION TURBINE IS HEATED IN THE EXTRACTION HEATERS OF THE OTHER UNIT

From the open heaters there is gravity flow to a header in the basement from which the feed pumps are tapped off. These discharge into a common header, which is in duplicate. Thence the feed passes through the two evaporator condensers, which are in parallel, then through the high-stage heater, and from there to the main feed header leading to the boilers. There is a secondary system of feed piping which leads from the secondary pump discharge header direct to each boiler, which it enters through an independent feed nozzle with hand control.

Four Stage Extraction

The original turbine unit is not equipped for stage bleeding, so that when it is operating alone the high-stage heater is inoperative and there is a corresponding drop in feed temperature. The new turbine is designed for bleeding at four points, of which the three higher are now in use. The first, or high pressure bleeder is connected directly to the high-stage heater; the second connects with the evaporator condensers, to make up any deficiency of steam when the evaporators are operating at low rating or out of service. The third bleeder is connected to the open heaters to supply any deficiency exhaust steam. Each heater connection is equipped with a sensitive automatic control, of the air-operated pilot type, which is set to maintain an even pressure in that particular unit. Each bleeder line is also equipped with non-return and shut-off valves.

Provision is also made to return any excess of exhaust steam to the main turbine through the low pressure No. 4 bleeder. This connection is also under automatic control, both from the exhaust pressure and also from the turbine throttle, to prevent backing up of steam when the unit is shut down.

As this plant operates under widely varying daily loads, there is a considerable amount of adjustment necessary to maintain any semblance of an average heat balance, and for this reason more attention has been given towards making the regulation as nearly automatic as circumstances would permit. It will be noted that a number of dual drives have been installed on the more vital auxilary units. This was done primarily as service insurance, but these units are also used for rough heat balance, serving as base control to some extent. All of these dual units are operated normally from the motor end, with just enough steam admitted for turbine cooling. The governors are set to start picking up load when the station frequency drops ½ cycle. For purposes of

PRINCIPAL EQUIPMENT AT KIDDER STATION

BOILER ROOM

Boilers—Riley Stoker Corp., 2 Badenhausen Class TL-30, 7500 sq. ft., 300 lb. pressure 4-drum boilers with 3¼ in. tubes. Mud drum set 10 ft. 9 in. above the grates.

Superheaters—Riley Stoker Corp., 2 Badenhausen, 1240 sq. ft. convection type, designed to give 170 deg. F. of superheat at 200 per cent rating.

Air Preheaters—Riley Stoker Corp., 2 Badenhausen, 6950 sq. ft. tubular type, designed to give 390 deg. F. exit air temperature at 200 per cent rating.

Soot Blowers—Bayer Co., Model K, 12 elements per boiler.

Stokers—Riley Stoker Corp., 4 Harrington traveling grate type (2 units per boiler), size 8 by 16 ft., with 6 air zones. Individual drive from 3 hp., 1160 r.p.m. constant speed General Electric motors through Reeves variable speed transmission.

Boiler Settings—Fuel Economy Engineering Co.

Arches—Bigelow Liptak Corp.

Water Columns—Reliance Gauge Column Co., No. 550 Micasight.

Feed Water Regulators—Northern Equipment Co., Copes.

Non-Return Valves—Lunkenheimer Co.

Blow-off Valves—Everlasting Valve Co., Yarnall Waring Co.

Induced Draft Fans—B. F. Sturtevant Co., 2, type MV, design 3, size 10, with a capacity of 66,000 c.f.m. at 400 deg. F., 6 in. w. g. Driven by Westinghouse 100-hp., 440 v., 690 r.p.m., type CW variable speed slip ring motors with hand control.

Forced Draft Fans—B. F. Sturtevant Co., 2, type TV, design 95, size 95, with a capacity of 40,500 c.f.m. at 70 deg. and 6 in. w. g. Driven by Westinghouse 50-hp., 440 v., 1750 r.p.m., type CW variable speed slip ring motors with hand control.

Combustion Control—Hagan Corp.

Boiler Meters—Republic Flow Meters Co., 2, indicating, integrating, 6-pen recording.

CO_2 Recorders—Republic Flow Meters Co., 2, electrically operated, remote recording.

Draft Gages—Republic Flow Meters Co., 4, two 9 element and two 7 element indicating.

COAL AND ASH HANDLING

Car Puller—Mead-Morrison Mfg. Co., No. 952 drum type with 5 hp. General Electric variable speed motor drive.

Crusher—Jeffrey Mfg. Co.. 18 by 18 in. single roll, driven through a belt by a Westinghouse 15 hp., type CS, 1160 r.p.m. motor.

Feeder—Chain Belt Co., reciprocating type, 24 in. wide by 8 ft. long. Driven by a Westinghouse 2 hp., 1160 r.p.m. motor through a D. O. James Mfg. Co. speed reducer.

Conveyor—Chain Belt Co., apron type, style B inclined, 18 in. wide, 25 ft. centers. Driven by a Westinghouse 3 hp., 1160 r.p.m. motor through a D. O. James Mfg. Co. reducer and chain.

Elevator—Chain Belt Co., V-bucket type elevator and conveyor. Buckets 12 by 15 by 3⅝ in., vertical centers 66 ft., horizontal centers 60 ft., speed 125 ft. per min. Driven by Westinghouse type CS, 10 hp., 1160 r.p.m. motor through a belt and D. O. James Mfg. Co. speed reducer.

Weigh Larry—Chain Belt Co., 2000 lb. capacity, driven by Allis-Chalmers 3 hp. motor through gears.

Bunkers—Chain Belt Co., steel plate suspended catenary type with no lining.

Ash Hoppers—Allen Sherman Hoff Co., Hydrojet, cast-iron suspended type with cast-iron troughs to sump.

Ash Pump—Allen Sherman Hoff Co., one 5 in. special manganese steel with capacity of 550 g.p.m. Driven by Westinghouse type CS 30 hp., 900 r.p.m. motor.

TURBINE ROOM

Turbo-Generator No. 1—General Electric Co., type R, 15 stage, 3600 r.p.m., 300 lb. pressure, 170 deg. F. superheat, 1½ in. back pressure, 3000 kw. turbine, direct connected to a type A.T.B., 2400 v., 3 ph., 60 cycle, 3750 kv.a., 0.8 P.F. generator.

Condenser—Worthington Pump & Machinery Corp., 3620 sq. ft., 2 pass, with capacity of 38,000 lb. of steam per hour with 4000 g.p.m. and 60 deg. cooling water.

Condensate Pumps—Worthington Pump & Machinery Corp., 2 Type S.D., 2 stage, 95 g.p.m., 40 ft. head, driven at 1750 r.p.m., by General Electric type KT 7½ hp., 1750 r.p.m. motors.

Vacuum Pump—Worthington Pump & Machinery Corp., 2 stage, duplex type ejector with surface inter and after cooler. Capacity 7 c.f.m.

Atmospheric Relief Valve—Worthington Pump & Machinery Corp.

Oil Filter—S. F. Bowser & Co., type AS 3, 90 g.p.h.

Turbo-Generator No. 2—Westinghouse Elec. & Mfg. Co., 3600 r.p.m., 300 lb., 170 deg. superheat, 1½ in. back pressure, 7500 kw. turbine, designed for stage bleeding at 4 points and driving a 3 ph., 60 cycle, 6900 v., 9375 kv.a., 0.8 P.F. generator and a 45 kw., 125 v., shunt wound, direct connected exciter.

Air Cooler—Griscom-Russell Co., 2 pass, 1920 sq. ft.

Condenser—Westinghouse Elec. & Mfg. Co., 8000 sq. ft., 2 pass with capacity of 90,000 lb. of steam per hour with 5000 g.p.m., 60 deg. cooling water. Welded steel shell with tubes rolled at both ends and the condenser suspended from the turbine.

Condensate Pump—Westinghouse Elec. & Mfg. Co., Type MS, 2 stage, with a capacity of 240 g.p.m. at 75 ft. head. Driven at 1160 r.p.m., by a 13 hp. Type 2AMD turbine, or a 15 hp. Type CS motor.

Vacuum Pump—Westinghouse Elec. & Mfg. Co., 2 stage, duplex type steam jet with surface inter and after coolers. Capacity 14.7 c.f.m.

Oil Filter—S. F. Bowser & Co., Type AS 3, 90 g.p.h.

Exciter—Westinghouse Elec. & Mfg. Co., 1, type SK, 50 kw., 1750 r.p.m., 125 v., compound wound with dual drive by a 75 hp. turbine or a 75 hp. type CS 2200 v. motor. One motor driven unit consisting of a type SK, 50 kw., 1150 r.p.m., 125 v., compound wound generator driven by a Type CS 75 hp. 2200 v. motor.

Circulating Pumps—Westinghouse Elec. & Mfg. Co., 4, size 12 in., double suction with capacity of 4000 g.p.m.; 2 pumps for 690 r.p.m. and a head of 34 ft. and 2 pumps for 1150 r.p.m. and a head of 20 ft. One unit has a dual drive consisting of a 45 hp., 3500 r.p.m. turbine with Type CS 50 hp. 690 r.p.m., 2400 v. motor; one unit motor driven through a Type CS, 50 hp., 690 r.p.m., 2400 v. motor; one motor driven through a Type CS, 40 hp., 1150 r.p.m., 2400 v. motor and one turbine driven by an Elliott Co. Type 3 BP, 30 hp., 1150 r.p.m. motor.

Suction Strainer—Elliott Co., Type F single, 16 in. size with ⅝ in. basket mesh.

Traveling Screens—Chain Belt Co., 5 ft. wide, 24 in. centers, speed 20 ft. per min., ⅜ in. screen mesh. Capacity 10,000 g.p.m., with 4 ft. submergence and velocity of 2.44 ft. per sec. Driven by Allis-Chalmers Mfg. Co. 3 hp., 1140 r.p.m. motors through D. O. James spur gear reducer and chain.

Boiler Feed Pumps—Allis-Chalmers Mfg. Co., 2, Type V, 4 stage, 3 by 2½ in., with a capacity of 150 g.p.m. at 750 ft. head, 3500 r.p.m. Driven by 65 hp., 3500 r.p.m., type BP2 Elliott Co. turbines.

Pump Governors—Fisher Governor Co.

Open Heater—Elliott Co., open deaerator type, with a capacity of 55,000 lb. per hr.

Open Heater—Hoppes Mfg. Co., open deaerator type with capacity of 60,000 lb. per hr.

Closed Heater—Whitlock Coil Pipe Co., 4 pass, Type S, high pressure heater with a capacity of 100,000 lb. per hr.

Evaporator Condenser—Whitlock Coil Pipe Co., 4 pass, Type S, with capacity of 50,000 lb. per hr.

Evaporator Condenser—Schutte & Koerting Co., Type FWH, No. 10, 4 pass, with a capacity of 50,000 lb. per hr.

Heater Traps—Armstrong Machine Works.

Relief Valve—Cochrane Corp., Multiport.

Evaporators—Schutte & Koerting Co., 2 No. 30 connected double effect evaporators with an output of 9400 lb. per hr., also 2 No. 12½ connected double effect with an output of 2500 lb. per hr.

Feed Control—Swartwout Co., Type SC.

Blow-off Valves—Everlasting Valve Co.

Evaporator Feed Heater—Swartwout Co. open type, capacity 8000 lb. per hr.

Evaporator Feed Heater—Fulton Foundry & Machinery Co., Class A open type, capacity 4000 lb. per hr.

Evaporator Feed Pump—Dayton Dowd Co., Type CSD, 1½ in., 2 stage, capacity 12 g.p.m. at 254 ft. head. Driven by Westinghouse 3450 r.p.m., 7½ hp., Type CS motor.

Evaporator Feed Pump—Goulds Pumps, Inc. Figure 34A, size 1½ by 2 in., single stage, double suction, capacity 25 g.p.m. at 350 ft. head. Driven by a Westinghouse 3600 r.p.m., Type CS 15 hp. motor.

High Pressure Pump—Allis-Chalmers Mfg. Co., 5 by 4 in., single stage, with capacity of 500 g.p.m. at 250 ft. head. Driven at 3500 r.p.m. by an Elliott 50 hp. turbine.

High Pressure Pump—Worthington Pump & Machinery Corp., 3 in., single stage, double suction with a capacity of 600 g.p.m., at 250 ft. head. Driven by a Westinghouse 50 hp. motor at 3500 r.p.m.

House Service Pumps—Worthington Pump & Machinery Corp., size 1½, single stage, double suction, with capacity of 75 g.p.m. at 100 ft. head. Driven by a 5 hp. General Electric motor.

Booster Pump—Chicago Pump Co. (used on low-pressure drains), capacity 10 g.p.m. at 40 ft. head. Driven by a ¾ hp., 1720 r.p.m. motor.

Turbine Room Metering Equipment—Republic Flow Meters Co., consisting of 2 turbine steam flow meters, 2 auxiliary steam flow meters and 1, 6-pen temperature and pressure recording instrument.

Recording Thermometers—Foxboro Co., 2 and 3 pen.

Vacuum Gages—Consolidated Ashcroft Hancock Co.

Indicating Thermometer—C. J. Tagliabue Mfg. Co.

Heater Controls—Swartwout Co., Type G master control, air actuated for heaters and bleeder connections.

Bleeder Non-Return Valves—Schutte & Koerting Co.

Turbine Room Crane—Armington Engineering Co.

Air Compressor—Ingersoll-Rand Co., 1 5 by 5, Type 20, 100 lb. pressure. Driven through reduction gears by a Westinghouse 15 hp., 870 r.p.m. motor.

Piping—(Old Part)
Fabricated headers & bends—Grinnell Co.
High-pressure valves—Walworth Co.
Low-pressure valves—Crane Co.
Fittings—Crane Co.
Midwest Piping & Supply Co.
Welded low-pressure piping—Wm. Bros Boiler & Mfg. Co.
Insulation—Johns-Manville.
Keasbey & Mattison Co.
Traps—Armstrong Machine Works.

Piping—(New Part)
Fabricated headers & bends—Crane Co.
Valves—Crane Co.
Fittings—Crane Co.
Welded low-pressure piping—Butler Mfg. Co.
Insulation—Johns-Manville.
Traps—Armstrong Machine Works.

ELECTRICAL EQUIPMENT

Switchboard & Meters—Westinghouse Elec. & Mfg. Co.

Switch Equipment & Control—Inside, Westinghouse Elec. & Mfg. Co. Outside, General Electric Co.

Voltage Regulators—General Electric Co.

Step-up Transformers—Allis-Chalmers Mfg. Co., Unit No. 1, 3, 1250 kv.a., single phase, 2300 to 23000/38000 v.; No. 2 unit, 1, 3 phase, 9000 kv.a., 6900 to 23000/38000 v.

Main Circuit Breaker—Westinghouse Elec. & Mfg. Co., Type BW, 7500 v., 1200 amps.

Service Transformer—General Electric Co., 3, 150 kv.a., Type H, 2300 to 440 v.

Storage Battery—Electric Storage Battery Co. Exide, 120 v., 60 cell.

Battery Charging Set—Westinghouse Elec. & Mfg. Co.

Lightning Arresters—General Electric Co.

Design & Engineering—Otter Tail Power Co.

heat balance the governors must be suitably adjusted by hand for a given condition.

Turbine-Generators

Exciter equipment consists of two 50 kw. units located on the main floor, one of which is motor driven and the other having dual drive. The first turbine was not equipped with direct connected exciter. In addition, the new turbine has its own direct connected exciter, which is of 45 kw. capacity and normally serves that machine alone. The two separate exciters may each be used alone or in parallel on the No. 1 machine and, by means of a throw-over switch, can also serve the new unit.

First turbine unit installed in 1927 is of General Electric make and is rated at 3750 kv.a. (3000 kw.) 3600 r.p.m. and operates on 300 lb., 175 deg. F. superheat steam and 28.5 in. vacuum. The generator is wound for 2400 v. and is not equipped with an air cooler, but air is drawn from inside the building and discharged outside. Its surface condenser is of the two pass type containing 3620 sq. ft. rated at 38,000 lb. steam per hour when supplied with 4000 g.p.m. circulating water at 60 deg. F. Motor driven condensate pumps of the double stage type are installed in duplicate inside the foundations below the condenser. Air removal is effected by a two stage air ejector with surface type inter and after coolers using condensate as the cooling medium.

The new Westinghouse unit, just put in service, is rated at 9375 kv.a. (7500 kw.) 3600 r.p.m. with steam and vacuum conditions the same as the old unit. The generator is wound for 6900 v. and is equipped with a surface type air cooler and closed air circulation. The cooler is connected in parallel with the main condenser and cooled with raw water. The surface condenser is two pass and contains 8000 sq. ft. The rating is 93,000 lb. steam per hour condensed with 7500 g.p.m. cooling water at 60 deg. F. The shell, together with the extended exhaust connection, is all of welded steel construction, water boxes cast iron, and tubes are rolled in solid at both ends. The operating weight is approximately 80,000 lb. and the entire unit is slung suspended from the turbine exhaust without other support. The double stage condensate pump is dual driven and is located in the basement inside the main foundation. A double two-stage air ejector is mounted on the turbine platform, the two pairs of stages exhausting into a common surface-type inter and after cooler. Only one set of nozzles is normally required, the other set serving as a reserve. Each turbine has its individual Republic metering panel.

Control and Distribution

Station control centers in the operating, or switchboard room, which is on the turbine gallery level and is completely glassed off from the turbine room. Here are located the main switchboard, outgoing line control-panels, station battery charging set and control. The switchboard is of standard design, using all-steel panels. All high tension equipment is located in a separate room, directly below the operating room, on the main floor. The 2400 and 6900 v. busses are mounted on separate steel racks above the oil circuit breakers. Breakers are of the remote-control electrically-operated type, the energy being supplied from the 110 v. station battery installed in a separate compartment off the operating room. The 2400 v. bus is installed in duplicate, one section serving as a transfer bus and connecting to the main bus through a remote controlled oil breaker.

Double-throw double-blade knife switches serve as transfer and disconnecting switches on the line side of each breaker, while on the bus side plain single-throw disconnects are installed. This arrangement allows any breaker to be disconnected for inspection and repairs without interrupting service. The 6900 v. equipment comprises the main generator breaker, with its disconnects and instrument transformers. The 2400 v. leads to the out-door step-up transformers are bare copper bars, which run out through a special tunnel to the substation. The 6900 v. leads are similarly run out in a separate tunnel.

In the outdoor substation are located three 1250 kv.a. step up transformers, delta connected on the low side, which step up the output of the No. 1 machine to 23,000/40,000 Y for transmission. For the No. 2 machine there is a single 3-phase transformer of 10,000 kv.a. capacity, 6900 to 23,000/40,000 volts, Y connected on the high side. Both groups are connected to the high bus through gang-operated disconnecting switches. Paralleling of the turbine units is done on the high bus, suitable potential transformers being provided for synchronizing. Each of the four outgoing lines is equipped with a remote-controlled electrically-operated oil breaker operated from the main switchboard. Disconnects are installed on each side of the breakers and also on the lightning arresters for each line. The overhead busses and disconnecting switches are mounted on a series of structural steel racks.

Power for station service is taken off the 2400 v. bus through an oil breaker and stepped down to 440 v., 3 phase, in a bank of three 150 kv.a. transformers located in the basement under the high tension room. The 440 v. distribution is made from a switchboard located on the main floor and built into the wall of the high tension room. Each separate circuit is taken off the 440 v. bus through an inclosed safety-type fused switch. All live parts are mounted inside the high tension room on the back of the distributing board.

Several of the larger motors in the plant are wound for 2400 v., and are served from a separate 2400 v. bus which is tapped off just ahead of the station transformer bank through a set of oil-break fuses. Each motor circuit is tapped off this bus through an automatic oil-switch mounted on the service board. All starting compensators are mounted back of inclosed steel-front panels adjacent to the units controlled.

Station lighting is furnished at 110/220 v., 3-wire, through separate transformers connected to the 2400 v. house bus. Certain essential lights throughout the plant are connected to a separate group of circuits, which are normally operated on A. C. current, but this group is cut over onto the station battery by an automatic transfer switch in the event of failure of the A. C. supply.

Normally the station operates on the system in parallel with a number of other plants, chief of which is the base load plant at Washburn, N. Dak., some 250 line miles distant. No trouble is now experienced in keeping in step with Washburn in spite of the distance and nominal transmission voltage. System disturbances would occasionally separate the two plants previous to the installation of heavier conductors between them.

The plant was named in memory of C. B. Kidder, one of the founders and the first general manager of the company, who was accidentally killed in the course of duty several years ago.

POWER PLANT ENGINEERING March 1933

DRAFT EQUIPMENT Must Fit COMBUSTION NEEDS

By
GEORGE C. DANIELS
Mechanical Engineer
The Commonwealth & Southern Corp.

Procedure in the Design of Forced and Induced Draft Systems for Boilers

IN SPITE of our accumulated knowledge and the advances made in the art of power plant design, it is interesting to note that haphazard methods still exist in the design and selection of boiler draft equipment. The capacity of a boiler installation has so often been limited and changes in the boiler layout made impossible by the lack of capacity in the draft system, especially in the induced draft, that plant operators have usually insisted upon ample capacity in the induced draft fan for all emergencies.

Experienced designing engineers, to meet this condition, frequently have figured their draft requirements liberally and then added thereto a large factor of safety, or perhaps a "factor of ignorance," to take care of the lack of definite information, possible changes in operating conditions or allowance for failure of the fans to meet the specifications. It has not been unusual to specify a fan to handle much more air or gas than necessary but the fan pressures have not been increased in proportion to the quantity of gas or air handled, so that the actual capacity of the fan is far less than expected. If the quantity of air or gas to be handled is increased 50 per cent beyond the normal maximum, as a factor of safety, then the fan pressures should be increased by 225 per cent of the normal maximum and the size of the driving unit by 337 per cent.

Such procedure can only result in increased capital and operating costs and make regulation more difficult. If the proper pressure and capacity relationship is not observed the fan will operate inefficiently at all loads. If the proper relationship between capacity and pressure is observed but too much excess draft capacity is provided the installation will be overmotored, resulting in inefficient operation and poor regulation.

In specifying a fan for forced or induced draft operation, it is, therefore, necessary to determine first, as accurately as possible, the maximum capacity and pressure at which the fan will have to operate. The maximum steam output per hour desired from a boiler can readily be ascertained and the entire boiler equipment designed accordingly. To obtain an output greatly in excess of this predetermined amount in actual operation is not an indication of good engineering or logical design, although usually not criticized as severely as would be the case if the design fell short of the predictions of capacity.

Having established the desired maximum steam output, the combustion rate can be determined and the boiler, heat recovery apparatus, fuel burning equipment and furnace size and design can be decided upon. It is then possible with existing available data to design the draft system and determine the draft losses with sufficient accuracy to permit specifying the correct size of fans, with a proper allowance for deviation from normal or expected operation.

For the calculation of fan capacities the procedure is then as follows:

General

1. Establish the desired maximum steam output from the boiler.
2. Estimate the efficiency of the combined boiler unit at the maximum output.
3. Calculate the amount of fuel per hour burned from the above.

Forced Draft Fan

4. Estimate the CO_2 in the furnace at the maximum steaming rate.
5. Calculate the pounds of air per hour for combustion corresponding to the CO_2 in the furnace.
6. Add a tolerance for leakage and abnormal operation, 5 to 10 per cent.
7. Change the quantity of air from pounds per hour to cubic feet per minute (C.F.M.) at the temperature of the inlet air to the fan.
8. Obtain the static pressure to be developed by the fan by adding the following pressures in inches of water:
   a. Air pressure required in wind box.
   b. Friction through air ducts and dampers.
   c. Friction through air preheater.
   d. Natural draft effect due to the difference of elevation of the air inlet and outlet, when air preheaters are used.
   e. To the sum of the above add 5 to 10 per cent for tolerance.

Induced Draft Fan

9. Estimate the CO_2 at the induced draft fan inlet by a proper deduction for leakage from the CO_2 in the furnace. For bituminous coal 1½ to 2 per cent is good practice, e.g., 14.5-2 = 12.5 per cent.
10. Calculate the pounds of flue gas per hour from the above CO_2 and the fuel burned per hour.
11. Add a tolerance for abnormal operation, 5 to 10 per cent.
12. Change the quantity of flue gas from pounds per hour to cubic feet per minute (C.F.M.) at the temperature of the gas entering the fan.
13. Obtain the static pressure to be developed by the fan by adding the following drafts in inches of water:

a. Negative pressure desired in the furnace.
b. Friction through boiler under average conditions of cleanliness.
c. Friction through economizer.
d. Friction through air preheater.
e. Friction through breechings, dampers and stack.
f. To the sum of the above add an allowance for slag accumulations and fouling, usually about 10 per cent.
g. Deduct from the above amount the natural draft.

Note—The static pressure developed by the fan should include the loss due to inlet boxes where they are used unless they are figured in the breeching friction loss, which is difficult unless the exact fan to be used is known.

The above procedure requires little comment, with the

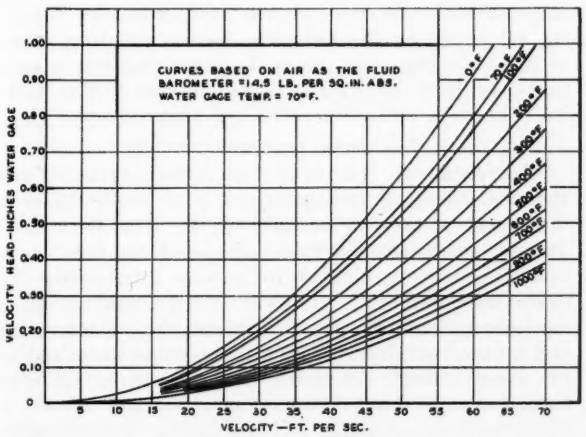

CURVES BASED ON AIR AS THE FLUID
BAROMETER = 14.5 LB. PER SQ. IN. ABS.
WATER GAGE TEMP. = 70° F.
VELOCITY HEAD—INCHES WATER GAGE
VELOCITY—FT. PER SEC.

FIG. 1. VELOCITY HEAD CORRESPONDING TO VELOCITY OF AIR IN DUCTS

possible exception of the determination of the friction or pressure loss through the air and flue gas ducts. The following formula and curves are based on air but can also be used for flue gas calculations without causing any appreciable error in the results.

Draft loss or friction in straight runs of a duct system can be calculated from the formula:

$$d = K \frac{fW^2CL}{A^3}$$

d = draft loss in inches of water.
W = pounds of air or gas flowing per second.
C = perimeter of duct in feet.
L = length of duct in feet.
f = coefficient of friction.
K = constant, depending upon the shape.
A = area of the duct in square feet.

f = 0.0015 for steel ducts at 600 deg. F.
f = 0.0011 for steel ducts at 350 deg. F.
f = 0.0020 for brick lined ducts at 600 deg. F.
f = 0.0015 for brick lined ducts at 350 deg. F.
K = 1.00 for round ducts.
K = 1.12 for square ducts.
K = 1.15 to 1.20 for rectangular ducts.

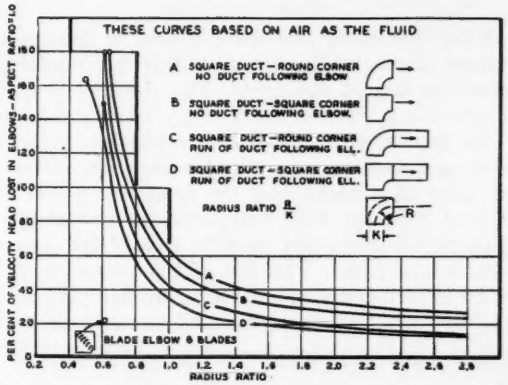

THESE CURVES BASED ON AIR AS THE FLUID
A SQUARE DUCT—ROUND CORNER NO DUCT FOLLOWING ELBOW
B SQUARE DUCT—SQUARE CORNER NO DUCT FOLLOWING ELBOW.
C SQUARE DUCT—ROUND CORNER RUN OF DUCT FOLLOWING ELL.
D SQUARE DUCT—SQUARE CORNER RUN OF DUCT FOLLOWING ELL.
RADIUS RATIO R/K
BLADE ELBOW 6 BLADES
PER CENT OF VELOCITY HEAD LOST IN ELBOWS—ASPECT RATIO=1.0
RADIUS RATIO

FIG. 2. RELATION OF VELOCITY HEAD LOSS IN ELBOWS TO RADIUS RATIO

The stack effect in the ducts or stack can be calculated as follows:

$$S = 7.55H\left(\frac{1}{T+460} - \frac{1}{t+460}\right)$$

S = stack effect in inches of water.
H = length of vertical run in feet.
T = temperature of outside air, degrees F.
t = temperature of air in duct, degrees F.

Friction in Bends

To determine the friction through bends and elbows by the following method, it is necessary to obtain the velocity head in inches of water corresponding to the velocity in feet per second. This can be read directly from the curves, Fig. 1, after calculating the velocity of the gas in the duct at the correct temperature. The per cent of velocity head loss in various types of elbows is shown by the curves in Figs. 2 and 3, the data for which were taken from Loring West's article in the General Electric Review, June, 1927. It will be noticed that an elbow with a square corner gives a lower loss than one with a round corner and that a blade elbow can be used instead of a long radius elbow with no greater friction loss.

Figure 4 shows the design of a blade elbow with a draft loss of approximately 22 per cent of the velocity head and Fig. 5 the design of an elbow with a splitter having a draft loss of approximately 40 per cent of the velocity head. The velocity head is lost where there is a

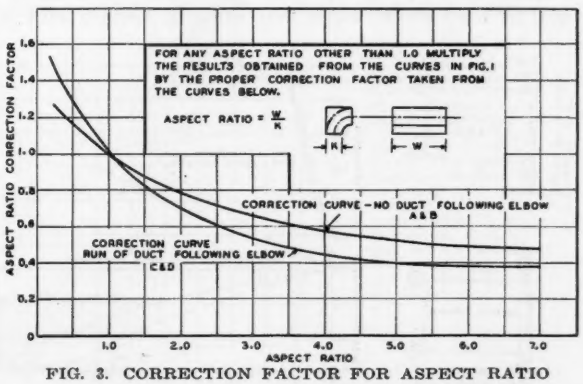

FOR ANY ASPECT RATIO OTHER THAN 1.0 MULTIPLY THE RESULTS OBTAINED FROM THE CURVES IN FIG. 1 BY THE PROPER CORRECTION FACTOR TAKEN FROM THE CURVES BELOW.
ASPECT RATIO = W/K
CORRECTION CURVE—NO DUCT FOLLOWING ELBOW A & B
CORRECTION CURVE RUN OF DUCT FOLLOWING ELBOW C & D
ASPECT RATIO CORRECTION FACTOR
ASPECT RATIO

FIG. 3. CORRECTION FACTOR FOR ASPECT RATIO

sudden increase in the size of the duct such as the entrance to the stoker wind box or the stack and it is generally safe to add to the friction losses the loss due to the velocity head.

Best Duct Size

While the above procedure is used to determine the pressure drops in the ducts it does not establish the economical size of the ducts. The size and shape of a considerable portion of the flue gas duct is determined by the apparatus to which it is connected, such as the boiler, economizer, air preheater and fan inlets. For long runs of straight duct the most economical size is obtained when the fixed charges on the cost of the duct including the insulation plus the cost of fan power are at the lowest point. The cost of the excess power over the estimated hours of operation at the various loads

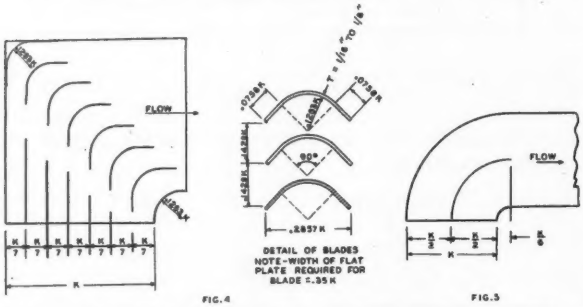


FIG. 4 FIG. 5

FIG. 4. DESIGN OF A BLADE ELBOW WHICH GIVES A DRAFT LOSS OF APPROXIMATELY 22 PER CENT OF VELOCITY HEAD

FIG. 5. ELBOW WITH SPLITTER GIVES DRAFT LOSS OF APPROXIMATELY 40 PER CENT OF VELOCITY HEAD

must include the fixed charges on any excess generator capacity required at the maximum load.

In any insulated duct system the cost, method of construction and the friction through the duct are somewhat dependent upon whether the insulation is applied on the outside or inside of the duct. Insulation applied to the inside of the duct has gained in favor due to the following reasons:

1. The temperature of the steel duct is lower and the expansion is greatly decreased.
2. The insulation is not as subject to being injured.
3. The duct is easier to paint and presents a better appearance.
4. The insulation is easier to apply, especially where large steel stiffening sections are used.

Disadvantages are that the insulation is harder to inspect and cannot be repaired in service. It cannot well be used where water may come in contact with it.

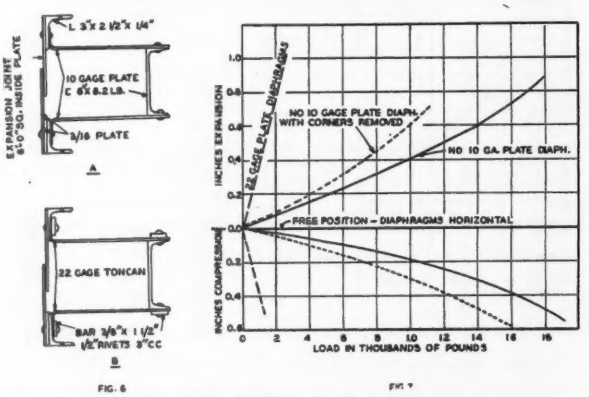


FIG. 6 FIG. 7

FIG. 6. SECTIONS THROUGH EXPANSION JOINTS

FIG. 7. FLEXIBILITY TESTS OF 6 BY 6-IN. EXPANSION JOINTS. SEE FIG. 6 FOR DETAILS

Occasionally scouring action of the ash in the flue gases erodes the insulation or even the steel ducts but this should not occur in well designed ducts.

Duct Expansion

Adequate provision for expansion in duct runs is necessary to prevent leakage of air with the attendant loss and increase in fan power. Inside insulation minimizes the temperature of the steel duct, but does not eliminate the necessity for providing for expansion. In duct runs with bends, sufficient flexibility is usually present if the supports are properly designed. In straight duct runs between fixed apparatus, expansion joints may be required. Very often the expansion joints that have been used are far too rigid, throwing heavy strains on the equipment or opening up joints in the duct work. Such a joint is shown in Fig. 6, which represents a common form of expansion joint in which the diaphragms are made of No. 10 gage steel plate. Such a joint for a 6 ft. by 6 ft. duct under tests for compression and extension gave results shown in Fig. 7. By replacing the No. 10 gage steel plate diaphragms with No. 22 gage steel plates the force required to compress the joint ½ in. was changed from 12,000 lb. to 1,200 lb. or a reduction of 90 per cent.

Activities of American Committee of the World Power Conference during its past year are outlined in the report of the chairman, O. C. Merrill. Because of present conditions, it was considered inadvisable to undertake a reorganization to increase membership and concentrate authority. Its objections to organization of an International Congress of Mechanical Engineering and a Chemical Engineering Congress were sustained by the International Executive Council. Approval of a Commission on Large Dams was given and a start is being made on collection and correlation of information from hydraulic research laboratories, through submission of quarterly reports to the U. S. Bureau of Standards in Washington, which will compile and issue a summary. Invitations to coöperate are being sent out to a list of some 100 laboratories and anyone interested in coöperating is asked to write either to the Bureau of Standards or to the American Committee, 1419 Chrysler Bldg., New York City. Laboratories are requested to submit the year established, equipment and kinds of work for which they are specially fitted, location and shipping facilities, name of person in charge and number of persons on the regular staff, summary of research already done or in process.

Chairman Merrill attended a meeting of the International Executive Council in Paris in June, 1932, to discuss the Stockholm sectional meeting for July, 1933, and act on various proposals submitted. The American Committee is now engaged in securing a few desirable papers for the Stockholm meeting. Final form for statistics on power resources and utilization was approved, which will make possible comparison of such data from various countries. Progress reports were received and discussed, especially the work of the Commission on Large Dams, which will consider at Stockholm the following: Deterioration by Age of Concrete in Gravity Dams; Influence of Internal Temperature on Deformation; Determination of Suitability of Material for Earth Dams; Laws of Infiltration of Water Through Earth Dams and Underlying Soil.

Pressure-Fired Boilers

By W. G. Noack

BEFORE the scientific annual meeting of the Ver. Deutsch Ing. in Berlin, a paper was presented on the development of the Brown-Boveri Velox-steam generator, the first report on this new design and the necessary experiments ever published.

Action of the Velox-steam generator is based upon the fact that heat transfer from gases to heating surface increases with rise of gas velocity and pressure. While gases in tubes usually flow at speeds of 33 to 50 ft. per sec. and in case of forced steam generation speed up to only about 98 ft. per sec., it is necessary to have velocity of 650 to 820 ft. per sec., at least, in order to obtain highest efficiency.

Besides high heat transfer, these high velocities, in connection with increased gas pressure have the advantage that the volume of gases is reduced so that the cross sections of gas passages can be cut down to a remarkably small amount, changing entirely the design of the boiler.

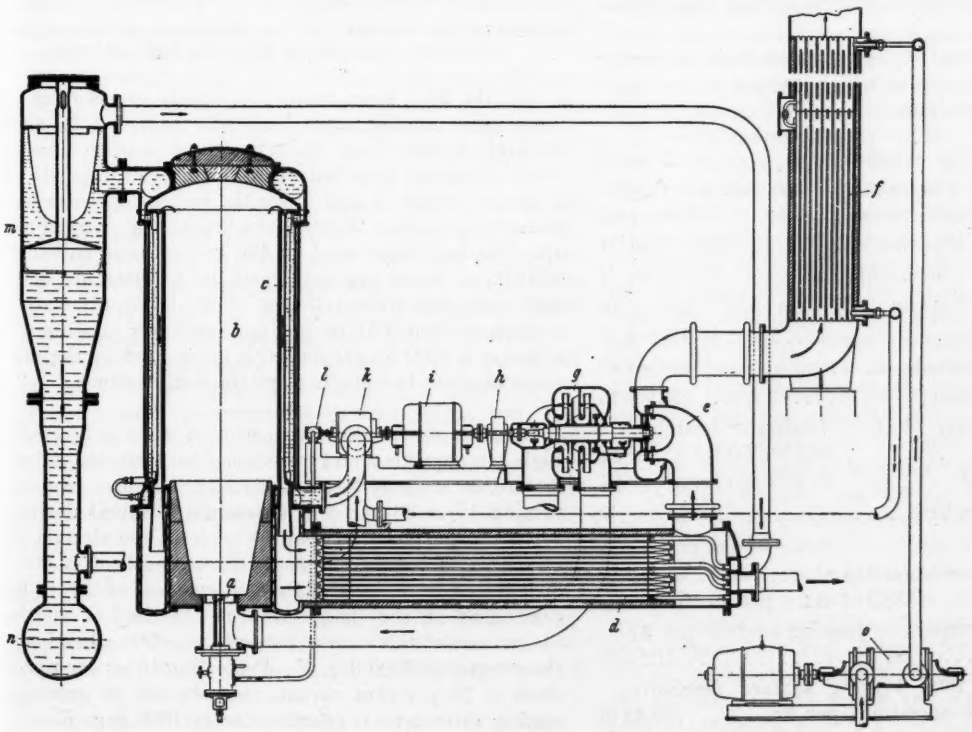
In working out the design of the new steam generator, the Brown-Boveri Co. has carried out a great number of experiments on heat transfer at very high gas speeds. Burned gases from city gas or heavy-oil mixtures were passed through pipes up to 13.1 ft. long with diameters from 0.4 up to 1 in. The gases had temperatures up to 2420 deg. F. The initial gas pressure was up to 83 lb. absolute in case of steady pressure combustion and up to 180 lb. abs. in case of explosion. The experiments were carried out with gas velocities up to 1378 ft. per sec. at the entrance of pipes.

Results so far obtained show that, in the entrance length of the pipe, heat transfer is almost twice as great as calculated by Nusselt's formula. In that part of the pipe where perfect turbulence of flow is realized, the difference between experiments and calculation is much smaller. The longest part of the pipe was, however, "entrance length."

Earlier tests seem to indicate that, at gas velocities of 300 ft. per sec. and over, heat transfer from compressible mediums depends on velocity, diameter of tubes, conductivity, specific heat, specific weight and viscosity of the gases. Further, the internal friction of gas flow, being almost proportional to the square of the velocity, causes a heating of the gases particularly in the boundary layer, thus promoting heat transfer.

Finally, at high velocities and pressures more than at low ones the specific volume of gases becomes much smaller because of rapid cooling, and this smaller

*Article in full is in Zeit d. Ver. Deutsch. Ing. No. 42/1932, p. 1033.



General Layout of Equal Pressure Velox-Steam Generator

a, burner; b, combustion chamber; c, evaporator tubes; d, superheater; e, gas turbine; f, economizer in chimney; g, compressor; h, reducing gear; i, auxiliary motor for starting and regulating; k, circulation pump; l, fuel pump; m, centrifugal steam separator; n, settling vessel; o, feed pump.

specific volume results in less kinetic energy, with rising potential energy, i.e., pressure. The effect is similar to that of a diffuser. It works to reduce pipe friction, so that the friction loss is smaller than calculated, since the usual calculation considers no "diffuser effect."

To increase gas pressure for pressure-firing, about 30 per cent of the boiler output would be necessary if the compressor were driven by a steam turbine or an electric motor. On the other hand, the energy necessary for the gas compressor can be obtained without affecting the boiler efficiency, if a gas turbine driven by the gases from the boiler is coupled with the compressor. This combination of gas turbine and boiler is called Velox-steam generator because it can be rapidly started to generating and brought up to the output demanded.

Two systems of these steam generators are designed; steady pressure and explosion types. For the explosion system, the combustion chamber is periodically charged by the compressor with an explosive fuel-air mixture, the inlet valves closed and the mixture ignited. Pressure rises to 4 to 5.5 times charging pressure. After the explosion (really after total combustion), the gases of combustion flow through an outlet valve into the heating tubes, evaporating the water which flows at high velocity outside of these tubes. After passing through the tubes at high velocity, the gases are checked before the nozzles of the gas turbine so that they have a large pressure drop to atmosphere. In order to obtain uniform output of the gas turbine, several combustion chambers are arranged.

For the steady-pressure system, the combustion chamber is also loaded with a compressed fuel-air mixture which, however, is not explosive. Pressure in the chamber is kept steady by a compressor driven by a gas turbine, which has to be arranged intermediate in the gas flow so that heating surfaces are both before and after the gas turbine. The illustration shows the general layout of a steady-pressure generator with gas-turbine-driven compressor.

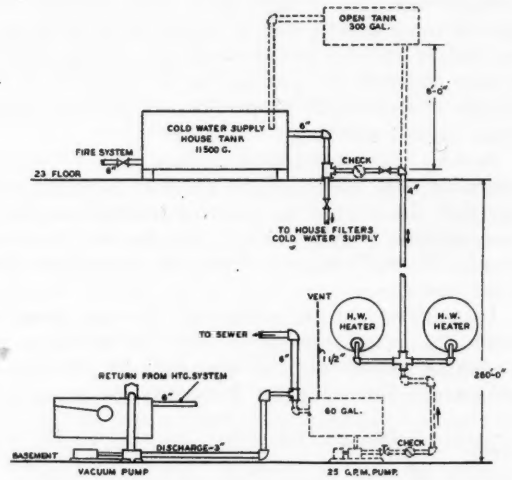
At the experiment station a Velox-steam generator gave the following results which seemed to be lower than the possible maximum:

Volume of combustion chamber	37 cu. ft.
Heating surface of evaporator (inside of gas tubes and outside of water tubes)	274.34 sq. ft.
Heating surface of superheater	285.25 sq. ft.
Heating surface of economizer	710.42 sq. ft.
Absolute pressure of steam	420 lb. per sq. in.
Steam temperature	716 deg. F.
Feedwater temperature	188 deg. F.
Steam output per hour	24,800 lb.
Heat content of steam (without feedwater heat)	30,119,350 B.t.u. per hr.
Heat content of fuel	32,857,120 B.t.u. per hr.
Exhaust gas temperature	320 deg. F.
Efficiency	About 90 per cent
Heat release in combustion chamber	883,464 B.t.u per cu. ft. per hr.
Steam per sq. ft. evaporator heating surface per hr.,	102.4 lb.
Steam per sq. ft. total heating surface (including superheater and economizer) per hr.	20.48 lb.

Piping Arranged to Save Hot Condensate

By Thomas Sheehan

HOW WE piped up a couple of tanks to use the returns from our heating system in our hot water tanks which formerly went to the sewer, as shown by the dotted lines in the sketch. This installation is in an office building with 70,000 sq. ft. of radiation. Steam is purchased from a central station and the returns are allowed to go to the sewer, which is the practice with the central station heating plant. The small 60 gal. tank was connected to the discharge from the vacuum pump and vented with a 1½-in. line above the sewer line. The discharge from the 25 g.p.m. pump was piped to the end of the cold water supply to the hot water tanks in the basement with a valve and check between.



REARRANGED PIPING AND EQUIPMENT SAVES HOT CONDENSATE AND STEAM FOR HEATING WATER

On the 23rd floor, where the supply comes from the house tank, another open tank was located 8 ft. above the highest water line, which is enough head to close the check which we installed in the cold water line. If the 25 g.p.m. pump is shut down the system operates as it formerly did, after the water in the 300 gal. tank is used up. The hot water used in the winter time called for 6000 lb. of steam per day when the temperature of the cold water was around 45 deg. Now the supply water is anywhere from 120 to 150 deg. and our consumption of steam is 1500 lb. per day, this being used by the night cleaners after the heating system is shut down.

Because of freedom from growth when subjected to high temperatures and resistance to corrosion after a first oxide scale is formed, high chrome cast iron containing 15 to 30 per cent chromium is found desirable for many purposes. It can be made in the electric furnace or in a cupola, shows tensile strength of 25,000 to 90,000 lb. per sq. in. and Brinell hardness of 228 to 600, depending on the composition and method of melting. Stoker bars of this material showed no effect when heated three times to 2000 deg. F. Protecting tubes for pyrometers of 15 per cent chrome iron showed no growth or scaling after several months' use at 1800 deg. F.

Turbine Blade Erosion

NEW METALS, LOWER TIP SPEEDS, HIGHER SUPERHEAT ARE HELPFUL. FROM N.E.L.A. REPORT

BLADE EROSION is one of the more serious problems of turbine maintenance and recent data indicate that outages from blade troubles have increased during the last year. In many cases these outages are due to blade erosion and attention has been directed to this difficulty in the hope that methods or materials may be developed as a result of these studies to mitigate or remove this cause of outage.

Blade erosion prevails in all makes of turbines, though it appears to be more serious in those low-pressure stages in which tip speeds exceed 950 f.p.s. and in which the moisture content is high. Erosion is much less troublesome on blading with tip speeds of 900 f.p.s. or where the steam has been reheated as on some high pressure units. The prevalence of erosion difficulties is evidenced by the fact that reports were received from 32 companies covering about 100 cases of blade erosion.

In the early stages of blade erosion, it has been the custom to build up the blades with silver solder. This has been effective in prolonging the wearing life of the blades. The life of blading where erosion has necessitated replacement varies from 3 to 8 yr. with an average life of about 5.5 yr. This replacement has become a significant item of maintenance expense. It is imperative that this difficulty be overcome in order to lessen operating costs and outages for replacement.

The moisture content at the last blade row appears to range from 10 to 14 per cent. Many turbines are being provided with drainage grooves in the last stages* and also with leak-off holes from these stages to the condenser but there are no definite data available on the effectiveness of such devices as moisture eliminators. Several cases were reported where serious erosion occurred at the dew point, suggesting the possibility of oxygen in the feedwater. This emphasizes the need of complete deaeration of the feedwater.

Eroded blading has generally been manganese bronze or nickel steels. The new blading materials are usually of stainless steel, Ascoloy or chrome iron. The useful lives of these materials have not been determined as few have been in use for a sufficiently long period.

Certain companies report rapid blade erosion on turbines which have operated for considerable periods at relatively light loads. One would normally not expect such action at light loads. An extreme case of corrosion was reported from a throttle governed 10,000-kw., 3600 r.p.m. Parsons turbine with a tip speed on the last row of 944 f.p.s. The moisture in the steam at exhaust varied from 13 to 14 per cent. The erosion took place in one year of almost continuous operation. This row was replaced by blading having sheaths of Hecla steel over the outer half of the blade. The new blading has been in service 2.5 yr. and has eroded about ⅛ in. on the portion of the blade adjacent to the inner end of the sheath.

A study of the data available indicated that erosion appeared to be dependent upon hours of operation, but did not seem to be directly related with load during those hours. The illustration shows erosion on the last blade row of an impulse-reaction turbine after 1 yr. of service. The tip speed of these blades was 977 f.p.s. and the moisture content from the Mollier diagram should not exceed 10.5 per cent at any load.

BLADE EROSION IN THE LOW PRESSURE STAGE OF A LARGE TURBINE

Eroded blades have been replaced to prevent breakage in service. The improvement in efficiency from such replacements has been a secondary consideration even though there may have been some loss in efficiency resulting from the erosion.

Erosion has generally been confined to the outer half of the blade and more particularly to a section 1.0 to 1.5 in. from the end of the blade. However, many companies have reported erosion of the front surface of the blades, particularly in the neighborhood of lacing wires.

Several companies report that increased superheat due to changes in the boiler plant appears to have effected a material reduction in blade erosion. It may be possible in other plants to lessen the trouble with blade erosion by increasing the station superheat.

Erosion appears in many cases to be most serious in the neighborhood of the outer lacing wire. Conditions have been improved in some cases of eroded blading on reaction turbines by moving the outer lacing wire to a position nearer the shaft. Ends of unshrouded reaction blading erode badly, thereby increasing the clearance between cylinder and casing and decreasing the efficiency of the unit. In some cases this decrease in efficiency was stated to be about 1.0 to 1.5 per cent.

Turbine builders are trying new blade materials, coatings for the wearing edges of blades and sheaths, in an endeavor to produce a blade which will withstand erosion. While this is commendable, it would seem better to devise some means for the elimination of moisture from the steam in the low-pressure stages. The devices tried*, both here and abroad, for such purpose, have not been wholly successful. This seems, however, to be the correct point of attack and deserves further study both by designers and by operators.

*See Draining Moisture from Turbines, Power Plant Engineering, p. 970, Oct. 1, 1931.

POWER PLANT ENGINEERING March 1933

Condensate Piping, Design Problems Met in the Power Plant

Plant Convenience and Economy Require Correct Arrangement of Condensate Equipment and Structural Details Prior to Final Design of Piping. By Henry C. Moffett*

IN TWO RECENT articles the main steam lines and boiler feedwater lines were discussed. These, together with the condensate lines, comprise the cycle of water and steam in power plant piping design, each part of which must carry practically the same quantity of water or steam per minute, but at different pressures, temperatures and specific volumes. A simple diagram of these three major parts is shown in Figure 1.

Pure water for make-up, to compensate for losses due to leaks, blowdowns and safety valve blow-offs, may be furnished by evaporators or by water softening and purifying systems. If evaporators are used, the vapors from them are led into the open or deaerating heater, where they are condensed, and the evaporator coil drains are trapped off and saved by piping them back to the

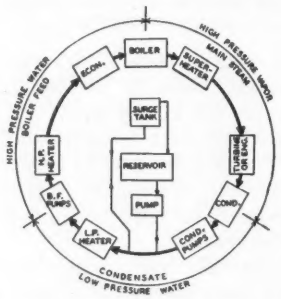


FIG. 1. THE POWER PLANT WATER RING

system at some point corresponding in pressure and temperature.

Surge Tank Piping

A surge tank provides a more or less constant pressure in the open heater, although the demand for water may vary considerably. If the fluctuations are great, the tank either overflows to the reservoir or pure water is pumped from the reservoir into the condensate system at some convenient point. Usually, some arrangement is provided so that if the surge tank level falls below a predetermined point, the make-up pumps are automatically started up, and as soon as the demand is met and the surge tank level is raised again to normal, the pumps are stopped.

It is good practice to make the condensate header, from the condensate pumps to the surge tank ample in size, as one of the prime requisites of any piping system is to be so constructed that boilers shall never lack water.

As a rule, especially in large turbo-generator stations, the condensate is pumped from the condenser hot-well through a low pressure heater, thence to an open or deaerating heater. This complicates the piping layouts and makes it necessary to calculate carefully the pressure drop in each part of the line, as well as through each heater, so that, if necessary, the maximum demand for water in the boilers can be made to flow against the surge tank pressure and into the open heater.

It is best to know in detail what the piping layout is to be before purchasing condensate pumps, so as to make sure the proper sizes are secured. Oversize pumps will waste power and undersized ones will not be able to pump sufficient water when required for the maximum demand. Large surge tanks and pure water reservoirs with ample auxiliary make-up pumps help meet this condition.

Figure 2 illustrates the usual system by a one-line diagram. Such diagrams will vary for each design of plant, but this one gives a general idea of the main fea-

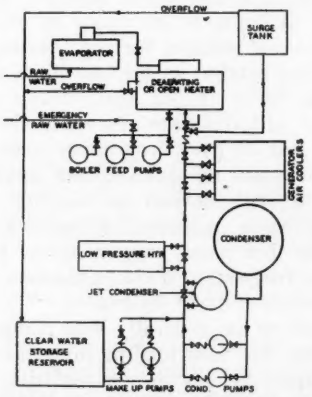


FIG. 2. CONVENTIONAL CONDENSATE PIPING DIAGRAM

tures. In this figure none of the pipe sizes are shown, whereas on a regularly constructed diagram they should be indicated. It is advisable to prepare a complete piping diagram of the piping for any condensate system, before attempting to design any of the lines in detail, as many short-cuts and improvements may become apparent from its preparation that might otherwise be overlooked in a complicated lay-out.

Condensate systems frequently include lines running to and from water weighing tanks. Condensate is shunted to these tanks during turbine or boiler tests, hence must be ample in size to weigh all of the water condensed. The tanks are in duplicate, beneath which are installed one or more pumps to return the weighed water to the regular condensate system. The necessary piping adds considerably to an already crowded arrangement, as weighing tanks, more often than not, are installed in a corner of a gallery, none too large for the usual mains. Space must be found for all valve wheels and levers, so as to be easily accessible, and in some cases this necessitates additional platforms and

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stairways. A skillful piping designer will foresee all such difficulties long before the details are gone into, and will work with the steel and concrete designers well in advance, so that ample room may be left for all the piping required.

Pipe Specifications

Pressure in condensate lines never reaches much above 50 lb. per sq. in., and therefore the piping is always specified as 125 lb. American standard. Practice for years has been to use cast-iron fittings and flanges for all low pressure and low temperature water lines. Recently, however, some of the better industrial plant engineers and many of the public utility engineers, have specified cast steel fittings and rolled or forged steel flanges for this work. There are two good reasons for this: first, to eliminate the breakage of cast-iron parts during shipment, erection or in service, and second, to secure a trouble free job at only a slight increase in cost. This, of course, applies only to the larger flanged fittings. The smaller fittings, 3 in. and below, are almost always malleable iron, and in the better plants, galvanized.

Steel pipe now manufactured in this country has been vastly improved in late years, and wide difference in corrosion resistance does not now exist between pipes made of steel and those made of genuine wrought iron. Many engineers, however, prefer the wrought iron for

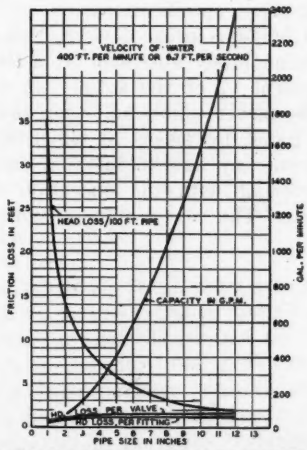

VELOCITY OF WATER
400 FT. PER MINUTE OR 6.7 FT. PER SECOND
HEAD LOSS/100 FT. PIPE
CAPACITY IN G.P.M.
HD. LOSS PER VALVE
NO LOSS PER FITTING
FRICTION LOSS IN FEET
GAL. PER MINUTE
PIPE SIZE IN INCHES

FIG. 3. FRICTION LOSSES AND CAPACITIES OF VARIOUS SIZE PIPE AND FITTINGS

pipes conveying hot water, especially when the water is intended for feeding boilers, and a great deal of it is used for this purpose. Wrought iron pipe is now made much more economically and efficiently than was the case even 5 or 6 yr. ago, and the prices are nearer the prices of steel pipe than before that time.

Size Piping Required

Many tables and charts are published which make it easy to find the relation of the flow of water in pipes to the velocity of flow. The following formula simplifies the calculations, when a chart or table is not available:

Let V equal the velocity of water in feet per second.

Let d equal the nominal pipe diameter.

Let GPM equal the number of gallons per minute flowing. Then,

$$V = 0.409\left(\frac{GPM}{d^2}\right) \text{ and } GPM = d^2\left(\frac{V}{0.409}\right).$$

or, $$d = \sqrt{\frac{0.409 \times GPM}{V}}.$$

Maximum velocity of flow for condensate should be about 10 ft. per sec., but a safer figure is around 400 ft. per min., or 6.67 ft. per sec. On this basis, the following table has been prepared, showing the usual range of pipe sizes met in practice for condensate. This shows the friction loss per 100 ft. of straight pipe.

Pipe Size Nominal In.	G.P.M. Flowing	Loss of Head Ft. Per 100 ft.	Loss of Head in Feet Globe Valve	Ell or Tee
1	18	35	.70	.70
1¼	30	24	.72	.63
1½	40	19	.76	.56
2	65	16	1.12	.80
2½	100	12	1.20	.84
3	140	9.5	1.24	.85
4	260	7.2	1.44	.94
5	410	6	1.68	1.14
6	590	4.5	1.62	1.10
8	1050	3.2	1.70	1.10
10	1600	2.5	1.75	1.17
12	2400	2	1.75	1.17

For all sizes of pipe in the above table, the velocity head ranges from about 0.6 to 0.7 ft., and for the given rate of flow, can be taken as 0.65 ft., as an approximate value. It is usually small in comparison to the total loss of head. As the velocities increase, the velocity head becomes more important.

Tight Joints Are Essential

One of the surest ways to secure a tight job is to specify that all flanges shall be screwed on past the pipe ends, and a re-facing cut taken on the flange face and on the end of the pipe. The gasket will then bear directly against the pipe end as well as against the flange. Good gaskets should be used and if cut on the job should be wide enough to extend past the flange faces. The inside cut should be smooth, and fit the inside diameter of the pipe end or fitting without overhang.

Bends should be used in place of ells wherever possible, both to cut down friction losses in the pipes, and to improve the appearance of the job. The use of pipe bends will also make fewer pipe joints necessary, and will care for all expansion and contraction in such lines. Double length pipe, for low pressure work, is available in practically all sizes that would be required for condensate piping, at only a slight increase in cost per foot. For jobs that are to be welded, these are especially advisable, as the elimination of some of the welded joints will constitute a saving in excess of the extra cost of the pipe.

Insulation is used on condensate piping only in those cases where the temperature of the water exceeds 130 deg. F., as it is not economically sound to cover pipes of lower temperature. In plants without bleeder or closed heaters, condensate piping from the pumps to the open heater is uncovered, as a rule, whereas in large turbine stations, all piping around stage heaters is most generally covered. Insulation of standard thickness is all that need be specified for any condensate piping.

POWER PLANT ENGINEERING March 1933

Hydraulic Equipment for the Hoover Power Plant

Construction of Power Plant and Excavation for Dam started Feb. 1. Details of Hydraulic Equipment as set forth in U. S. Government specifications.

WITH THE WORK OF constructing the great diversion tunnels nearing completion, the next job of major importance at the Boulder Canyon project is the actual excavation for the Hoover Dam and the construction of the power plant itself. Excavation work for the dam as well as construction of the power plant is now being started. Because of the great general interest of this project, not alone because of its magnitude but also because of its unique place in our economic structure, the most important details of this plant will be described briefly in this article, the material for which was taken directly from the specifications issued by the U. S. Bureau of Reclamation.

A general idea of the project may be had from the plan shown in Fig. 1. The plant will be located immediately downstream from the dam and will be a U-shaped structure with the base of the U across the river on the downstream toe of the dam and one wing on each side of the river. The main generating units will be installed in the wings of the power plant and the central or connecting portion will contain the station service units, sump pumps, machine shop, control and auxiliary equipment. The plant is being laid out for an ultimate installation of 15 50-cycle main generating units of 82,500 kv-a. capacity each and two 60-cycle main generating units of 40,000 kv-a. capacity each. The initial installation will comprise three, four or five of the 50-cycle, 82,500 kv-a. units and one or two 60-cycle, 40,000 kv-a. units. The 82,500 kv-a. units will be designed for possible future operation at 60 cycles by means of changes of turbine runners. The general arrangement of the power plant, dam, intake towers, pen-stocks and outlets is shown on the drawings accompanying these specifications.

There will be four intake towers; two on each side of the river immediately upstream from the dam. Each tower will control ¼ of the supply of water for the turbines in the power plant, and each tower will have two cylinder gates, by means of which the water can be shut off from any one of the four main penstocks without interfering with the operation of the other three penstocks. The lower cylinder gates will be at

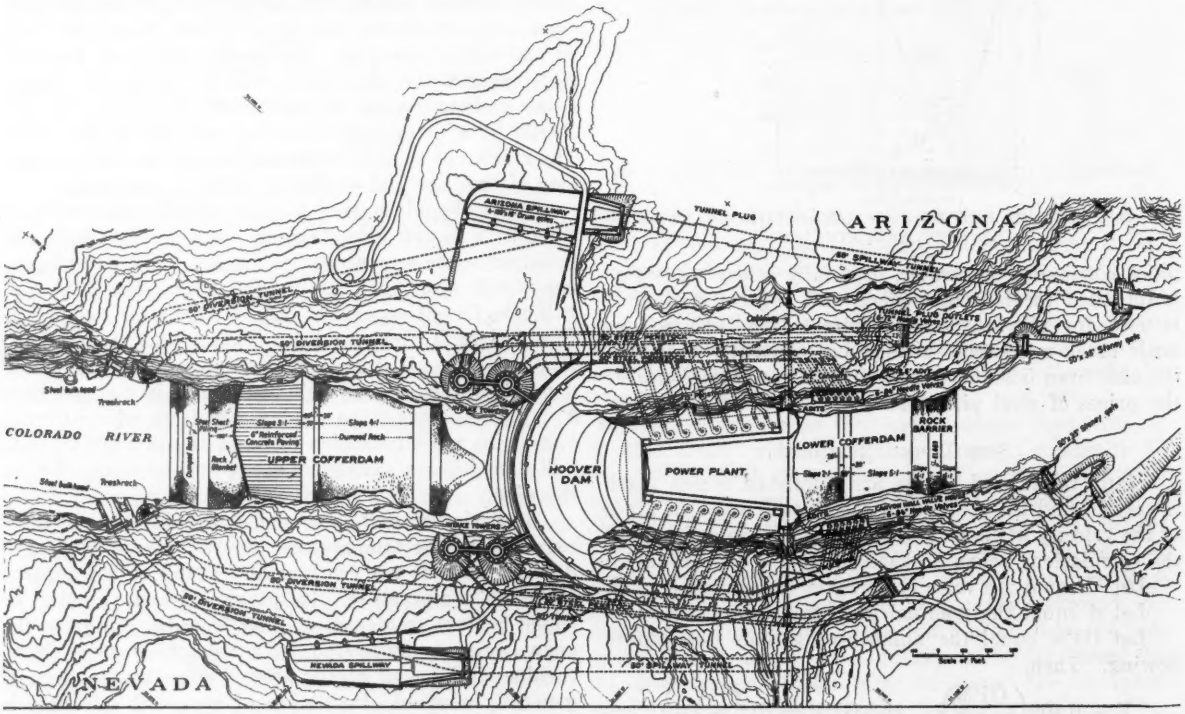


FIG. 1. GENERAL PLAN OF THE HOOVER DAM DEVELOPMENT

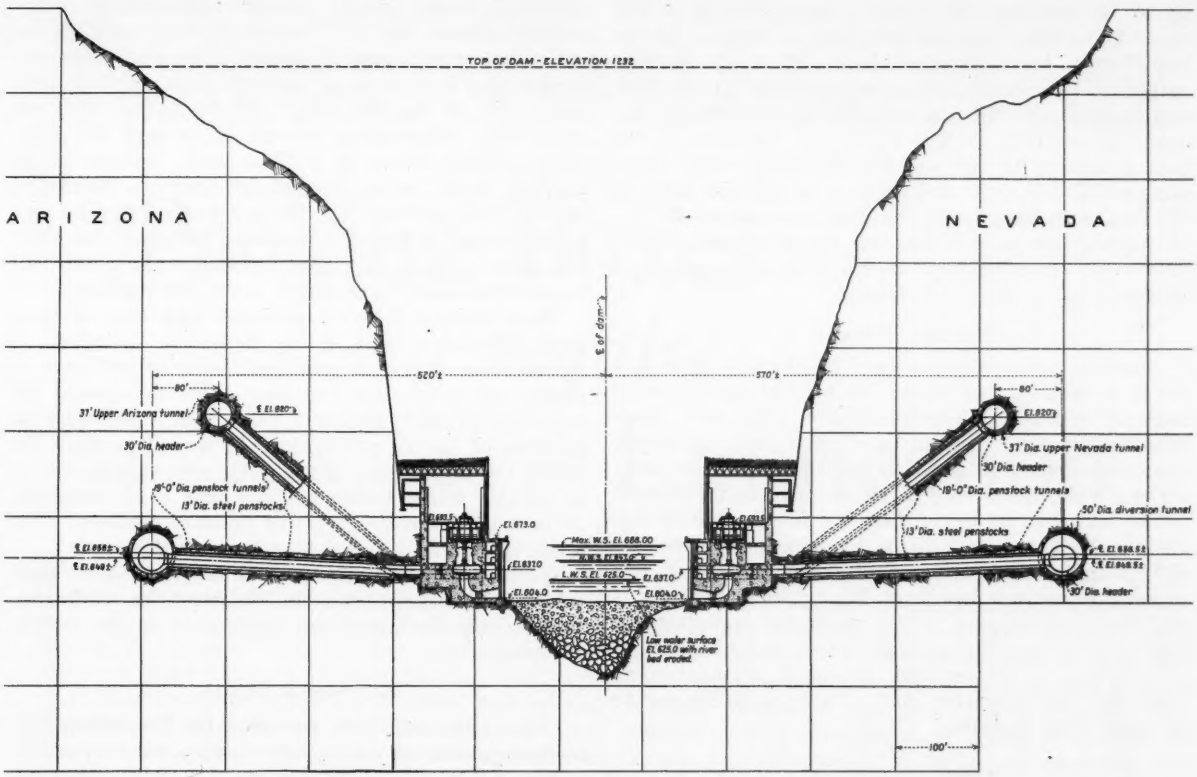


FIG. 2. CROSS SECTION THROUGH POWER PLANT

elevation 894 and the upper cylinder gates will be at elevation 1045. The intake towers will be provided with means for placing emergency bulkhead gates over the entrances to the cylinder gates so that the latter may be unwatered for inspection and maintenance purposes, and trash racks will be provided over the entrances to the intake towers.

Steel penstocks 30 ft. in diameter installed in two of the 50 ft. diameter diversion tunnels and in the two main penstock tunnels will conduct the water from the intake towers to the individual penstocks and to outlet valves. Each 30 ft. diameter penstock will connect with four branch penstocks each 13 ft. in diameter which will conduct water to the main turbines. The two 55,000-hp. turbines, however, will both be connected to the downstream 13 ft. diameter branch penstock from the upper or penstock tunnel on the Arizona side. The three initial 115,000-hp. turbines will be connected to branch penstocks from the upper tunnels on either side of the river. A butterfly type shut-off valve will be installed at the inlet to each turbine casing.

Hydraulic Turbines

The hydraulic turbines are to be of the vertical shaft, single runner, spiral casing type. The 115,000-hp. units are to operate at a speed of 150 r.p.m. but will be designed so that they may also be operated safely at a speed of 180 r.p.m. with no major change in any part of the apparatus except the installation of new runners designed for the higher speed. The generators to which these turbines will be connected will have 40 poles and will operate at 50 cycles but at some future date the frequency may be changed to 60 cycles. The 55,000-hp. turbines will operate at a speed of 257-1/7 r.p.m. The generators to which these turbines will be connected will have 28 poles and will operate at 60 cycles only.

Surface elevation of the water in the reservoir will fluctuate from a maximum at elevation 1229 with the flood storage capacity completely full to a minimum at about elevation 1050. Under present conditions the surface of the water in the river at the dam site with a low water flow of 12,000 second ft. is at about elevation 647 and with a discharge of 100,000 sec. ft. the water surface in the river immediately below the dam is at about elevation 666.

It is expected that loose material in the river bed below the dam will be gradually eroded by the clear water released from the reservoir and that this will result in somewhat lower elevation of tail water in the future than exists at the present time. In order to provide for this possibility, the power plant is being designed for a minimum tail-water surface at elevation 625. The net effective head under which the turbines will operate may vary from a minimum of about 420 ft. to a maximum of 590 ft.

These extreme head conditions will occur only at infrequent intervals and will be of short duration and for 90 per cent of the time the net effective head will be between 450 and 560 ft. It is expected that the head on the turbines when first installed may be as low as 300 ft. and that it may be a few months thereafter before the head is at 420 ft. or more. During this period the average head on the turbines is expected to be about 325 ft. No sacrifice in efficiency at the higher heads is to be made in order to improve performance at the lower heads during the initial period of operation.

Each of the 115,000-hp. turbines will have a capac-

ity of not less than 90,000-hp. when operating at 150 r.p.m. and under a net effective head of 420 ft. As the net effective head increases above 420 ft. the turbine output will increase up to a maximum of 115,000-hp., corresponding to full generator rating of 82,500 kw. at unity power factor. The 55,000-hp. turbines are to have a capacity of not less than 44,000-hp. when operating at 257-1/7 r.p.m. and under a net effective head of 420 ft. As the net effective head increases above 420 ft., the turbine output will increase up to a maximum of 55,000-hp., corresponding to full generator rating of 40,000-kw. at unity power factor.

Turbine Details

Turbine runners are to be of the Francis type and are to be made of cast steel. The turbine shaft is to be made of forged open-hearth carbon or alloy steel, properly heat treated. It is to be of ample size to operate at any speed up to full runaway speed at maximum head without vibration or objectionable distortion but shall not be less than 38 in. in diameter for the 115,000-hp. units and not less than 25 in. in diameter for the 55,000-hp. units. The turbine shaft is to be made in two sections to facilitate handling. The upper section of this shaft is to be shipped to the generator manufacturer who is to fit it to the generator shaft and who will be responsible for the accurate alinement of the turbine shaft with the generator shaft. Taper bolts are not to be used in the coupling.

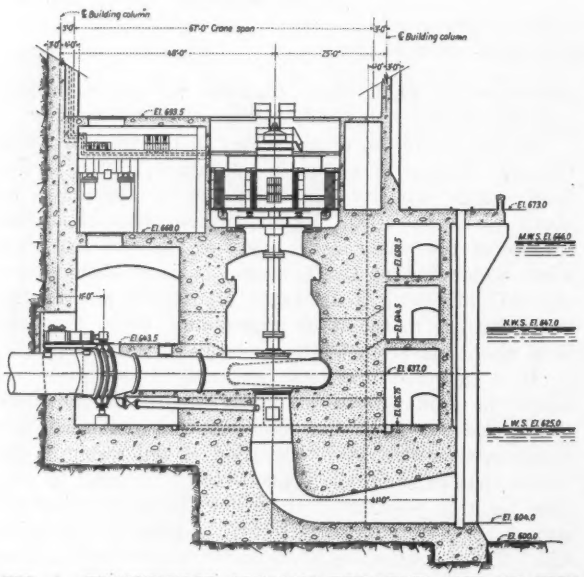


FIG. 3. TRANSVERSE SECTION THROUGH ONE OF THE 55,000-HP. UNITS

Guide bearings on the main turbine are to be of the babbit-lined oil lubricated type located above the runners and will consist of a bearing support and a removable bearing shaft. The bearing support in the bearing and the bearing itself will be split vertically so as to facilitate dismantling. The guide bearing shall be provided with two thermostat relays to close contacts upon a predetermined temperature of the bearing combined with two dial type temperature indicators with the temperature detecting elements imbedded in the anti-friction metal of the bearing, one near each end.

Lubrication of the turbine guide bearing is to be effected by oil circulated through the bearing. Two independent motor driven positive displacement rotary type oil pumps are to be provided for circulating the oil. These pumps may be mounted separate from the turbine and located at or near the main turbine floor level. One of the oil pumps will be driven by a 60-cycle 220-v. alternating current motor and the other pump will be driven by a 125-v. direct current motor supplied from the station storage battery. Normally, the oil will be circulated by the a.c. motor pumping unit but on failure of the oil pressure or failure of the alternating current supply, the direct current motor will start automatically and supply oil to the bearings.

Each turbine is to be provided with two oil pressure operated double acting hydraulic cylinders or servo-motors having a combined capacity sufficient to supply the maximum necessary force to operate the gates and pressure regulator valve with a minimum oil pressure of 150 lb. per sq. in. At the oil pressure for which the system is designed, the servo-motors are to be capable under maximum operating head conditions of moving the turbine gates and pressure regulator valve a full opening or a full closing stroke in 4 seconds.

In construction of the draft tubes, each bidder shall submit with his proposal the design of the draft tube upon which the guaranteed efficiencies of the turbine are based.

Butterfly Valves

Under the schedules provided for furnishing butterfly type shut-off valves with turbines, 14 ft. diameter valves will be furnished for the 115,000-hp. turbines and 10 ft. diameter valves for the 55,000-hp. turbines. The butterfly valves are to be located between the lower ends of the penstocks and the inlets of the corresponding turbine casings. These valves are to be used as shut-off valves for the hydraulic turbines and in normal operation they will be operated with no flow in the penstocks except the amount due to leakage through the turbine wicket gates. The valves will not be closed until after the turbine wicket gates have been closed and the valves will not be opened until after the turbine casings have been filled by means of bypass valves and pressures in the turbine casing and penstocks have been equalized. For operating the valves, the source of power will be 460 or 230 v. 3 phase, 60 cycle current. The control of each main valve and its service bypass valve for both opening and closing will be from two control stations, one near the valve and one at the main switchboard. Each control station will be provided with push button controls for starting the valve movement in either direction and for stopping movement and restarting in either direction at any point of valve travel.

Governors

Turbine governors are to be of the oil pressure, relay valve, actuator type with electrically driven responsive element. The governors and auxiliary equipment will have adequate capacity to supply the necessary quantity of oil to the servo-motors to operate the turbine gates and pressure regulator valves through a complete closing or through a complete opening stroke in 4 sec. with minimum oil pressure of 150 lb. per sq. in. and the turbine operating under the maximum head. The speed responsive element of each actuator will be driven by alternating current generators.

Power Utilization

Packing Boxes *require* Lubrication

by Reginald Trautschold

FAULTY PACKINGS can cause not only power waste but great damage to equipment resulting in large expense for upkeep and replacement. When a packing box develops a leak, the first move is to tighten up on the gland plenty, without considering that packing friction and journal friction are akin, that increasing either will aggravate trouble. A shaft or rod scored from excessive gland pressure may be more serious than a scored shaft, as location of the packing can seldom be altered and expensive repairs are entailed.

Contrary to general belief, packing is in a stuffing box, not to prevent leakage but to serve as a means of maintaining a seal of lubricant around the moving part. It is the function of the lubricant to prevent leakage.

Importance of packing lubrication cannot be overemphasized, for upon it depends not only prevention of leakage and effective seal, but the durability of the packing material and low packing friction. The lubricant may be graphite or some compound with which the packing material is impregnated, as is customary where flexible packing is employed, or it may be applied separately, as in the case of metallic packings of the floating type.

Lubricant should be of such character and so carried that it will withstand the washing-out action of the vapors or liquids with which it may come in contact. Where acid and alkaline solutions are encountered, resistance to their action is of major importance, as once

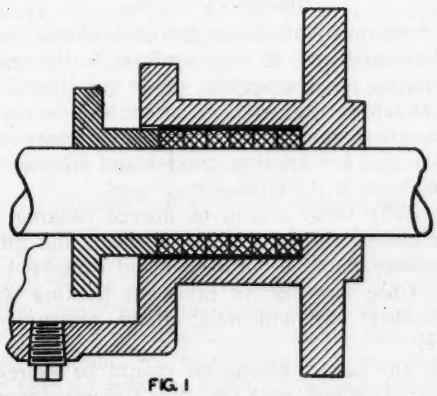


FIG. 1

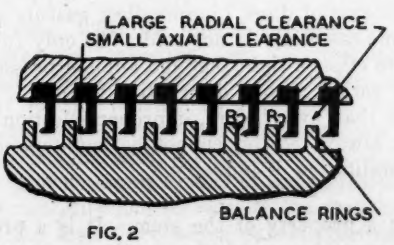


FIG. 2

FIG. 1. LUBRICATION FORMS THE SEAL IN A STUFFING BOX

FIG. 2. WATER FILM IS THE LUBRICATING SEAL IN A LABYRINTH PACKING

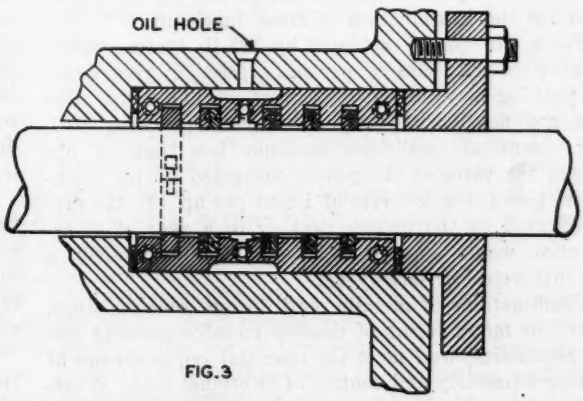


FIG. 3

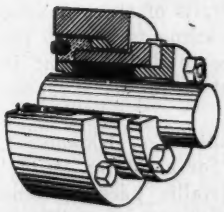


FIG. 4

FIG. 3. FLOATING METALLIC PACKINGS REQUIRE A LUBRICATION FILM

FIG. 4. FLEXIBLE METALLIC AND SEMI-METALLIC PACKINGS CARRY AN IMPREGNATION OF LUBRICANT TO MAINTAIN THE SEAL

the lubrication of the packing is destroyed the packing is not only ineffective, but becomes of the nature of a destructive agent and should be replaced promptly.

Clearance needed for the accommodation of the lubricant interposed between the packing material and the reciprocating rod or shaft depends, naturally, upon the viscosity of the lubricant employed, but is considerably greater than might be imagined. This is illustrated in a convincing manner by the results secured with so-termed labyrinth packings in steam turbines, Fig. 2, used to control leakage of steam between successive pressure stages. With the clearance at edges of the rings made from 0.01 to 0.015 in., the leakage of steam under considerable pressure through the labyrinth packing can be held down to 2 or 3 per cent, the number of rings varying with the steam pressure; but the amount of leakage varies with the clearance.

Packing clearance required is considerably less than labyrinth ring clearance as the viscosity of the lubricant is much greater than that of the steam actuating the turbine. Consequently, it is not at all surprising that a packing box of standard proportions will, with suitably lubricated packing material, prevent leakage even under conditions of very heavy pressure. Clearance is in reality quite small and there is always grave danger of the lubricant film being punctured by the packing material when take-up of the stuffing-box gland is attempted.

METALLIC PACKINGS, FLOATING AND FLEXIBLE

Where solid metallic packings of the floating variety are employed, that may be considered incompressible, the lubricant film obviously forms the seal between the shaft or rod and the packing rings. When kept suitably lubricated, these packings have given 20 and 30 yr. of service. A lubricant of suitable consistency and quality has to be employed, of course, and proper facilities provided for the introduction of fresh lubricant.

For a 3-in. piston, actuated by 125 lb. steam, traveling at a speed of 600 ft. per min., friction from tight, dry packing may amount to something like 5 hp. The same rod fitted with proper lubricated packing will, under identical conditions, consume less than ¼ hp. Placing the value of the power consumed by the packing friction at the low rate of 1 cent per hp.-hr., the saving effected by the proper packing in a year of 24-hr. operation would amount to between $340 and $350, a sum that would be largely net.

Combinations of metallic and fibrous packing rings, as well as many forms of flexible metallic packing sets and assemblies, well meet the essential requirements of packing durability and control of frictional load. Whatever may be the constructional details of these flexible metallic packings, the metallic constituents furnish the desirable durability and resistance to displacement in service, while the fibrous material serves as a repository for the essential lubricant.

At the Western Board & Paper Co., Kalamazoo, Mich., for example, a large pump for handling "stuff" was first packed with flexible metallic packing some 10 or 12 yr. ago and ran 2½ yr. with only the addition of two rings to the original complement, to supply more lubricant as the original supply was slowly consumed. It was then found necessary to remove the packing, not because it became dry, but to remove an accumulation of pins, staples and abrasive materials in the stuffing-box. A second packing with the same material gave similar service for another 2½ yr.

With a form of packing, consisting of granules of suitable packing metal alloy intimately mixed with a similar proportion of wood granules thoroughly impregnated with a suitable lubricant by a boiling process, the packing is placed in a stuffing-box, in the form of packing rings. Tightening of the gland causes the granules to arrange themselves to conform with the shape of the rod or shaft, during which adjustment there is a short period in which the packing heats up. As soon as the packing has formed and the lubricant squeezed from the wood granules has created the essential lubricant film, the packing cools off and remains cool. When there is indication of a leak, slight take-up will effect a prompt re-seal, the granules composing the body of the packing being free to move with slight movement of the stuffing-box gland, liberating the required replenishment of sealing lubricant.

Tests were made on a pump in boiler feed water service, packed with this distinctive semi-metallic packing. With only 60 lb. air pressure actuating the pump, an effort was made to stop the pump by tightening-up on the stuffing-box gland, a 6-ft. wrench being used but, despite the great pressure applied, the pump could not be stopped. The same attempt was made with steam at 40-lb. pressure actuating the pump, but with no greater success.

In this connection, D. J. Smith, chief engineer of the Paulsen Medical and Dental Buildings, Spokane, Wash., said in Feb., 1932: "A two-stage centrifugal pump, running 1800 r.p.m., pumping against 150 lb. pressure was packed July 2, 1924, and to date (the pump runs five months out of the year) there has only been one ring added to the discharge end."

FIBROUS PACKINGS

For most revolving shafts, however, fibrous packings are widely used and, if they conform to the essentials for rendering packing service, prove quite satisfactory, as well as low in first cost. In order to meet two basic requirements for economical and satisfactory service, durability and low friction, proper and adequate packing lubrication is the outstanding need.

Practically every strand of fibrous packing should be impregnated with a suitable lubricant and lubricant qualifications should be protected and conserved to the utmost. Once an effective lubricant packing seal has been created, any additional gland pressure is destructive.

Much the same precautions should be exercised in the use of wick and rope packings for valve stems and all services in which friction exacts a waste of power. Of course, in the case of discs, pump valves, gaskets and washers, the same essentials do not hold. The only function of these is to effect a tight seal and applied pressure is a productive rather than a destructive factor.

Today, more than ever before, improper selection or packing abuse, always costly, cannot be countenanced during the rehabilitation of industry.

HEAT is not a property of the atom. It is a property only of a mass, i.e., a relative motion among the atoms of a mass. If all the atoms of a mass would move together in the same direction and at the same velocity, no heat would be generated.

Lubrication of Anti-Friction Bearings

By K. A. Newman*

IN ANY INDUSTRIAL plant which operates a few hundred ball bearings will be found ten to twenty different ball bearing lubrication problems. Variable mechanical factors which affect not only the choice of lubricant but the performance of that lubricant are: Size, load, speed, operating temperatures, design of bearing housing.

Oil Preferable

Housings of ball or roller bearings, which vary in construction depending on the maker, predetermine whether oil or grease shall be used as a lubricant. If all ball and roller bearings were so designed that oil could be used as a lubricant, it is our belief that 75 per cent of the lubrication problems on these bearings would be eliminated. This step would add considerably to the cost of production and is, therefore, considered impracticable. The reason that highest lubrication efficiency is attained in bearings designed for oil lubrication is that oil naturally offers less resistance to the motion of the rolling sliding parts than does grease.

Temperature Effect

Operating temperatures are important in choosing a lubricant, since the viscosity of oil and the body or consistency of grease decrease rapidly under the influence of heat. Changes in operating temperatures result from conduction of heat to or from the bearing from outside sources along the shaft, through the casing or by the surrounding air. The temperature may be either above or below the normal prevailing room temperature, i.e., an operating temperature of 30 deg. F. can exist just as readily as a temperature of 250 deg. F.

Faulty lubrication of anti-friction bearings will result, if one lubricant is used for all the ball and roller bearings in a plant regardless of temperatures or operating conditions. While adoption in its entirety of the chart given may not be feasible in many plants, a compromise chart for standard lubrication can be compiled using this as a guide.

Greases at High Temperatures

High operating temperatures cause grease to become softer in consistency. In many greases a soap filler is combined with a light-bodied mineral oil by mechanical agitation under heat, the proportions of oil and soap being varied to produce the consistency required in the finished product. In operation, heat and centrifugal action tend to separate these component parts and on shutting down, not all of the oil will be reabsorbed by the filler, especially since the stirring action of the rotating balls or rollers has ceased. This condition, known as "bleeding" or "separation," if continued over a period of time will cause free oil to be thrown out of the bearing by cenrtifugal force so that the remaining mixture gradually becomes drier and has poorer lubricating properties.

Hardening or drying of some greases is accompanied by rancidity and increase in the free fatty acid content of the soap filler which causes corrosion, but this can be avoided by the use of high quality greases, which will not deteriorate with age.

*The Houghton Research Staff.

Water, which enters into making the soap must be completely eliminated from the finished product, as its presence will cause hydrolysis, resulting in rapid decomposition of the grease and increase in the free fatty acid content.

Low Soap Content in Greases

Ideal greases would contain no soap or other filler since soap is less efficient than oil as a lubricant. The higher the percentage of soap in a grease, the lower its lubricating efficiency, also the greater the tendency to separate and harden in service.

Developing greases to contain the lowest possible percentage of filler has been the subject of intensive research, the success being evidenced by recently developed ball bearing greases which contain from 2 to 5 per cent of filler, about one-tenth the amount ordinarily used.

OIL RECOMMENDATIONS

Saybolt Viscosity of Recommended Oils at 100 Deg. F.

Operating Temp. Deg. F.	Normal Loads		Heavy Loads
	Normal Speeds	High Speeds	Normal Speeds
0 - 32	100*	82*	100*
33 - 60	100*	82*	120*
61 - 95	105	82	160
96 -125	160	100	400
126 -150	530	400	700
151 -180	945	530	1500
181 and over	Steam Cyl.Oil	1500	Steam Cyl.Oil

Note: *These oils should have a cold test of not less than -35 Deg. F.

GREASE RECOMMENDATIONS

Operating Temp.Deg.F.	Normal Loads				Heavy Loads	
	Normal Speeds		High Speeds		Normal Speeds	
	Consis-tency	Melting Pt.Deg.F.	Consis-tency	Melting Pt.Deg.F.	Consis-tency	Melting Pt.Deg.F.
0 - 30	Soft	150	Soft	150	Soft	150
31 - 75	Soft	150	Soft	150	Soft	150
76 -100	Med.	160	Med.	160	Med.	160
101 -150	Med.	250	Med.	250	Hard	300
151 -170	Hard	300	Hard	300	Extra Hd.	350
171 and over	Steam Cyl.Oil		Steam Cyl.Oil		Hvy.Stm.Cyl.Oil	

As greases are usually mechanical mixtures of soap, resin and light mineral oils agitated at high temperatures, the heat assisting in their formation, heat in service results in their destruction. In the new anti-friction bearing greases ingredients are not merely mechanical mixtures but are combined in colloidal form into a stable mixture which cannot separate in service.

Grease Selection

In grease lubrication it is important to select the proper grade or consistency as well as to use a high quality. The tables herewith have been prepared, as a result of wide experience in lubricating anti-friction bearings in industrial equipment, to show the approximate viscosity of oil and consistency of grease to be used under various combinations of loads, speeds and operating temperatures. Most operating engineers, recognizing the need of using different grades of oil to meet different operating conditions, would not think of using the same oil in a small motor bearing that they would in a large bearing operating under heavy loads and possibly at elevated temperatures. The same factors should be considered in selecting grease. By checking operating conditions against the tables it will usually be found that two or possibly three different grades of grease should be kept in stock to meet the lubrication requirements of all types of equipment.

Ammonia Condenser of New Design

A STUDY OF the reasons for the high heat transfers obtainable in modern shell and tube condensers resulted in the conviction that where space was of secondary importance the shell and tube condenser could be duplicated in effect without the use of heads and shell. Such a condenser has been designed by H. C. Guild and is now being brought into production by several licensed manufacturers.

The object of this design is to place nearly 100 per cent of the weight of the condenser in condensing surface; to reduce maintenance costs by having all water surfaces accessible for inspection, repairs or cleaning; to make possible an even, measurable film of water that can be regulated; to use substantial corrosion resistant material; to maintain wetted surfaces on both water and ammonia sides at all times; and to provide the shortest, most direct path for condensate from condensing surface to liquid header.

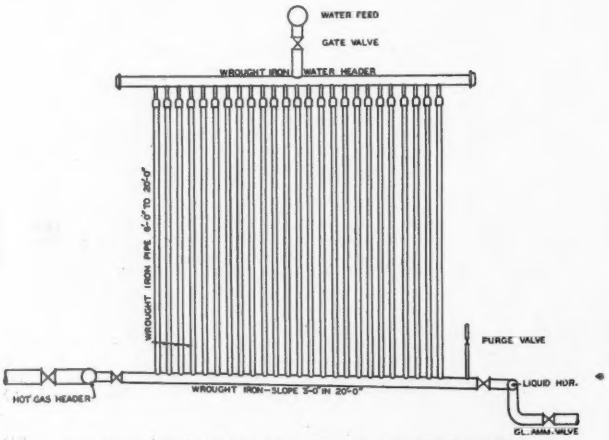


FIG. 1. ELEVATION AND PLAN OF CONDENSER ARRANGEMENT

This type of condenser consists essentially of a number of vertical pipes, the lower ends of which are welded into a combination gas and liquid header, which is given enough slope to permit good condensate drainage. The upper ends of the vertical pipes are closed by filler plates welded in place. The header and vertical pipes may be any size, but the header is usually 2½ in. and the vertical pipes 2 in. diameter. The vertical pipes are ordinarily placed on 4-in. centers and may vary in length from 8 to 20 ft. A cup-shaped, adjustable water nozzle connected by a short running-thread nipple to the water header is placed over the upper end of each vertical pipe. This nozzle distributes and regulates the flow of water on the outer surface of the vertical pipe.

Number of vertical pipes per stand may be varied as desired, the stands being usually spaced 18 to 36 in. apart, thus permitting easy access.

Substantial construction and resistance to corrosion are secured by using standard weight lap-welded genuine wrought iron pipe. In order to save space and basin costs, this type of condenser may be placed either in the cooling tower or spray pond.

From a main header, cooling water is distributed to the condenser through down pipes to horizontal distributor pipes, one of which is located immediately above each stand of vertical pipes. Into the lower side of the distributors are welded ½ inch running-thread nipples spaced the same distance apart as the vertical condenser pipes. The cup-shaped water nozzles are screwed onto the nipples and distribute the water over the vertical pipes, each nozzle being provided with three lugs spaced 120 deg., which center the nozzle over the end of the pipe. Water flows through the annular space thus formed and onto the outer surface of the pipe. Dirt and algae accumulations are eliminated in this type of condenser by use of the closed water system.

Condensate Disposal

As the ammonia condenses on the inside surface of the vertical pipes, it flows quickly and directly to the liquid header where it is drawn off into the receiver. In rapidly flowing to the liquid header, the condensate by washing action on the condensing surfaces keeps

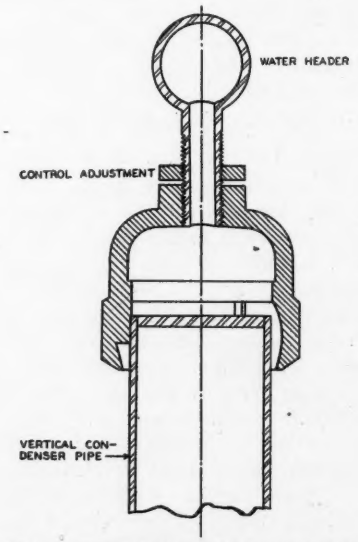


FIG. 2. DETAIL OF WATER NOZZLE

them free from oil and scale that would otherwise collect. This, combined with the fact that incoming hot gas is always in direct contact with the wetted condensing surface, makes high heat transfers possible.

Purging

Presence of non-condensable gases in any condenser will result in lower condensing temperature but higher head pressure, due to the sum of the partial pressure of the various gases. This lowers the rate of heat transfer by decreasing the difference between condensing vapor temperature and mean water temperature. The presence of such gases is indicated by condensate leaving the condenser at a temperature below that which corresponds to condenser pressure.

Contrary to popular opinion, non-condensable gases do not stratify or isolate themselves in a condenser. They will diffuse and mix with the ammonia gas in accordance with the laws of gases but, in any condenser, such gases tend to attain a higher percentage of concentration at the point of least activity.

When this new type condenser was being developed, a gas-tapping arrangement was tried at the top of each vertical pipe but tests revealed no indication of an ex-

cess of non-condensable gases at any point. Finally, two methods of purging were found satisfactory: Closing the inlet and outlet valves on one stand at a time and opening the purge tap located as shown in Fig. 1, thus reducing the pressure in that stand and at the same time lowering the temperature; or attaching any standard purge device to the purge tap.

A number of condensers of this design have been in service for several years and have proved entirely satisfactory. Water losses due to windage have been eliminated in this type of condenser, thus reducing pumping costs.

Electric Heating of Steel Plates

By A. W. Hill*

IN THE modern oil circuit breaker the tank top, or dome, is frequently pressed to shape, requiring the use of furnaces for heating or annealing the plates and electric furnaces are found satisfactory because of their simplicity and ease of control.

Each furnace has a floor area approximately 9 ft. square and clear height of 30 in. A door across the entire front is raised and lowered by a motor, which is cut off automatically at full travel by limit switches. To prevent leakage the closed door is forced tightly against the furnace wall by use of cams. Heating elements consist of ribbon conductors mounted in the floor and roof, the work to be heated being laid on rails spaced 4 in. above the lower heating element.

Designed for 1000 deg. C. operation and rated at 150 kw., 3-phase, 60-cycle, 200 v., a thermostat cuts the furnace heating elements into or out of the circuit with

THREE CIRCUIT BREAKER TOPS IN ELECTRIC FURNACE FOR ANNEALING. TRAVEL LIMIT SWITCHES AT RIGHT. TIGHT-CLOSING DOOR CAMS AT EACH END

variation of temperature not more than 2 to 3 deg. In case the load is to be very light, the transformer windings are reconnected from star to delta, thus reducing the operating voltage to 58 per cent of normal and giving one-third of normal electrical capacity. One thermocouple is located in the extreme inner part of the furnace and one at the side near the door, the latter quickly detecting the effect of an open door, or of cold material being loaded into the furnace, hence used to operate the thermostatic control.

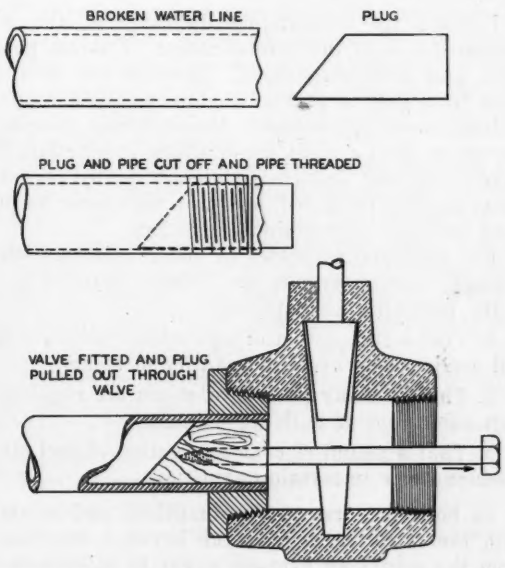
*Westinghouse Electric and Manufacturing Co.

Large, thick pieces being formed to a simple flanged dome shape are pressed hot, as the load on the press becomes excessive when the piece is not heated. Lighter pieces, up to approximately ½ in. thick, are pressed cold, which permits of greater deformation of metal without tearing or unequal reduction of section than when pressed hot. The total amount of work done on some of these shapes becomes so great, however, that several operations are required and, in cases such as these, it becomes necessary to normalize the piece between operations, at temperature of around 800 deg. C. the work being held in the furnace only long enough to insure that it has been heated clear through. It is then allowed to cool in the open air before being put into the press for the next operation. Complicated shapes are normalized as many as six times, the final pressing being done hot, a sizing operation involving almost no work beyond bringing the piece to final accurate dimensions.

Plugging a Broken Pipe Line

Where a water line breaks and no cut-off valve is ahead of the break, it is difficult to make a repair. Outside lines which are subject to frost and those subject to end strain can be repaired without much concern as the water rarely does damage other than to empty a cistern.

For use where a line breaks, a beveled taper plug as shown in the drawing will prove of value. The pipe should be taken or cut entirely off, for which purpose it may require a pipe cutter. Then, the plug is driven



STEPS IN THE REPAIR OF A BROKEN PIPE

into the pipe, the bevel allowing easy entrance against the force of the water and also directing the stream to one side. Once caulked, the pipe is squared off, threaded and a valve screwed on. A straight through valve should be obtained, otherwise it will be necessary to remove the plug before putting on the valve.

The plug is pulled with a lag screw or similar coarse threaded wood screw, using a hammer to back the plug out.

Washington, D. C. G. A. Luers.

POWER PLANT ENGINEERING March 1933

Sale of Steam Requires Just Rate

SEVERAL METHODS OF ESTIMATING STEAM HEATING REQUIREMENTS ANALYZED; BILLING METHODS BASED ON UNIT COSTS CITED. BY ROBERT EMERICK*

STEAM, as a material of commerce, seems to have escaped any general standardization of price, and so quite naturally when some thought is being given to the purchase of it or to the selling of some to a neighbor, there is the problem of how much should be paid or charged. If there is a district steam heating company in town, its rates are valuable guideposts on manners and methods, but in using such data it should be remembered that they have been formulated to reach the widest possible market and individual problems are best solved on the basis of individual conditions.

For the seller, these conditions are primarily the costs and limitations of generation. Increased steam output involves an increased fuel bill, perhaps more labor, sometimes more maintenance. Plant changes necessary in order to supply the service may be extensive and their cost must be figured into the asking price and so ultimately borne by the purchaser. Against these factors of additional expense, however, the increased generation not infrequently allows a plant to operate with improved overall efficiency and thus diminish the cost of unit output.

METHODS OF ESTIMATING STEAM REQUIREMENTS

Perhaps the outstanding difficulty of the whole proposition is in the determination of steam productions past and anticipated. Records are invariably made from year to year of obvious operating expenses as fuel, labor, ash removal, maintenance, compounds, but rarely does a plant meter steam production. Then there is no real knowledge of how many pounds of steam the fuel produced, and unit costs must be predicated therefore on certain assumptions.

For example, estimates of steam consumption for a simple heating system are usually founded on one of the following assumptions:

1. That a square foot of equivalent direct radiation will condense an average quantity of steam.

2. That so many pounds of steam are required for each cubic foot of building volume.

3. That a pound of coal or a gallon of fuel oil will produce steam in certain quantities.

In both the first two assumptions and sometimes with the third, average is the keynote, but how far from the actual an average might be is indicated by an examination of approximately 20 buildings, all located within a few blocks of each other. Steam consumptions, when applied to the square feet of equivalent direct radiation, ranged from 200 lb. to 900 lb. per sq. ft. during a single heating season. When considered in relation to volume, the steam used in the same year varied between 2 lb. and 12 lb. per cu. ft. of volume. In practice, individual cases should be studied most critically with the aim of evaluating all apparent deviations from the average and modifying the average accordingly.

*The Philadelphia Steam Company.

ACCURACY OF ESTIMATES BASED ON FUEL CONSUMPTION

In so far as the third assumption is concerned, the Philadelphia Steam Co. is compiling records and collecting data which at present are not complete, but in their present stage they point to this third assumption as being the most satisfactory and accurate method of estimating. One case carried through several years shows an accuracy of prediction almost unbelievable. This particular building used 1,164,800 lb. of coal during the heating season of 1928-29. Condition of the boilers, general operating factors, feedwater practice, and all those other many contributors to boiler room output indicated that an all year average evaporation of 6 lb. of steam per pound of coal would be about right. Thus an estimated steam production of 6,988,800 lb. was reached. In the city, however, where this building was located, that season of 1928-29 was only 89 per cent as cold as normal and in modifying the estimate to place it on a normal basis, a new figure of 7,852,360 lb. was obtained and which was felt to represent the steam requirements of that property during a 100 per cent normal winter. During the next two winters the records show up like this:

Winter	1929-30	1930-31
Per cent Normal	93	95
Estimated Consumption* Corrected to Per cent Normal...	7,302,695	7,459,742
Actual Consumption as Measured	7,323,708	7,292,257
Estimated Error in lb. + or —	—21,003	+167,485

*Estimated consumption = 7,852,360 lb. for a 100 per cent normal year.

One laboratory study such as this is not to be considered as arguing conclusively in favor of the third assumption, yet the result is rather startling and certainly fuel consumption seems to be a most reasonable basis from which to begin evaporation calculations. Care, however, in recognizing contributing factors to the average evaporation is essential. Test figures, if available, are probably of most value in their indication of a limit beyond which output cannot go.

Apparently the superior accuracy of the third assumption is due to its reflection of operating conditions. Bad firing or good, mild or severe weather, the desires of building occupants for warmth or coolness, are all recorded in the rate of fuel consumption. Assumptions No. 1 and No. 2 seem to be less circumscribing, and allowances for individual conditions are likely to be rather vague owing to the difficulties attendant to turning appearances into measurable certainties. Comparison of the relationships among radiation, volume and consumption of three office buildings show the following:

	Bldg. No. 1	Bldg. No. 2	Bldg. No. 3
Volume per sq. ft. rad. cu. ft..	48	86	93
Cons. per sq. ft. rad. lb.....	310	488	205
Cons. per sq. ft. vol. lb.....	6.39	5.09	2.97

There is probably no definite rule governing consumption as a result of the radiation-volume ratio. There is no greatly obvious difference in the equipment of any one of these three buildings from the other two. Building No. 3 is the most modern by several years and the fact that it shows least consumption per square foot of radiation and also per cubic foot of volume leads to the belief that in modifying averages, they should be scaled downward when considering the latest structures and systems.

Whatever system or method of estimating is followed, all evidence emphasizes the desirability of compiling the estimate with thorough caution. The weather bureau of each locality should be consulted for data on normal weather and existing trends, and estimated results weighed accordingly.

Unit Costs of Steam Service

With the steam production of a plant approximated by estimate, or measured in those plants that are outfitted with proper instruments, unit costs are readily obtained. These unit costs, usually expressed as so much per thousand pounds of steam, then form the basis for further computations which consider the magnitude of plant changes, increased fuel, maintenance, supplies, and miscellaneous items following the institution of steam service to an outside customer.

If the prospective customer has been operating a boiler plant of his own, his steam demands may be satisfactorily computed in the same manner used for determining steam production in the plant of the seller. If the structure to be heated or the process to be served is a new one without previous operating records, heat losses and rates of condensation must be calculated in accordance with the standard formulae. The expenditure of steam through open jets or nozzles may be evaluated likewise and it is of interest that some district steam companies have special rates for such uses of their product.

With unit costs, customer's requirements and production problems all arranged in good shape, there is next the question of billing. Inspection of methods indicates a variety of characters, each no doubt eminently suited to the conditions under which it is applied. At this stage, the prospective purchaser is likely to have a great deal to say. Particularly is this so if he thinks the price too high, and he does frequently, because non-technical owners and executives are prone to discount boiler room expenses other than fuel. Just how wide is the range of billing methods, may be appreciated by inspection of the rates being employed by district heating companies. In the order of their frequency, that is most frequent first, these methods appear to be as follows:

1. To meter the steam or condensate and charge for the quantities so measured at so much per thousand pounds.

2. To meter and charge as in method No. 1, but to have in addition a stand-by or ready-to-serve charge based on the greatest hourly use in pounds as recorded on a special instrument. Sometimes the hourly use basis is disregarded in favor of a charge fixed by the number of square feet of equivalent direct radiation. In this method, the cost of steam per thousand pounds as metered is usually much less than in Method No. 1, as the stand-by charge contributes largely to the total cost.

3. To meter and charge as in Method No. 1, but to have in addition a stand-by or ready-to-serve charge based on the cubic feet of building volume.

There are other methods not nearly so frequently seen as the three cited, and some of them are described without any reference to the frequency of their occurrence. They are:

1. A single charge of so much per square foot of equivalent direct radiation.

2. A fixed lump sum charged annually plus a billing for steam used, at so much for each thousand pounds.

3. A single charge of so much per cubic foot of building volume.

A secondary feature often found in operating steam rates is known as the fuel adjustment clause. Under this clause, fluctuations in the cost of fuel to the steam producer, are transferred to the customer in the form of increases or decreases to the published rate, thus giving the customer the benefit of falling prices and protecting the steam seller against a rising market. Less frequently this clause is extended to provide also for fluctuations in labor rates.

Flat Rate Not Equitable

Among industrial users of steam, a type of charge quite common, is that of a flat sum agreed to by the seller and the purchaser. This method allows the purchaser to draw steam from the mains of the seller at will, without any limitation of times or quantities. This method, however, does not appear to be equitable, as, despite careful preliminary calculations, changing conditions during the effective period of the agreement are almost certain to cause a loss to one or the other of the contracting parties.

While the seller's prime concern in selecting a rate is to be sure that it will satisfactorily meet the fundamental costs of generation and distribution, the purchaser views the rate from another angle, the angle of desire. The nature of this desire varies, not so widely as might be expected. A city group of 16 buildings reporting on their reasons for purchasing steam, turned in information of this sort:

Nine, or 56 per cent, said they found it cheaper to buy steam than to generate it.

Two, or 13 per cent, required boiler room areas for other, and they felt, more important use.

Two were chiefly concerned with the convenience and lack of responsibility.

One, or 6 per cent, reported steam needs in excess of existing plant capacity.

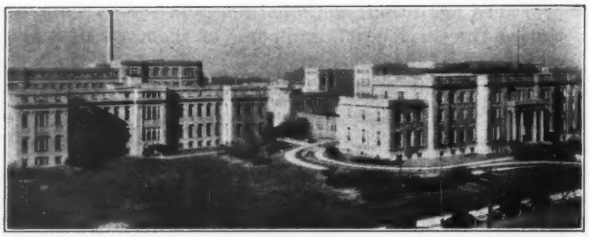
One claimed a combination of saving and space needs.

One denoted a monetary saving allied with the desire for convenience.

From this data, it appears that the purchaser in more than half of all negotiations, will have mainly in mind, the idea of saving in operating costs, and the seller, if he can discover this fact, should keep it in mind when adopting a rate. The margin of saving is likely to be narrow rather than otherwise, and the negotiations will have to be completed within close limits.

POWER PLANT ENGINEERING March 1933

Power Plant Analysis for



CINCINNATI GENERAL HOSPITAL

From Data Supplied by Anthony A. Fette
Superintendent of Power and Maintenance

FOR HOSPITAL SERVICE, current is needed for lighting; motors for ventilation, elevators, pumping, laundry and laboratory work; steam for cooking, sterilizing, laundry and heating; water, both hot and cold for laundry and house service.

As an instructive example of good management, an analysis made by Anthony A. Fette, superintendent of power and maintenance of the Cincinnati General Hospital, has much of value. This hospital showed a growth from 450 patients daily in 1923 to 870 in 1930, with a drop in 1931 to 840. The power plant, in a separate building at the rear, indicated by the chimney in the headpiece, has stoker-fed boilers serviced by a weigh larry, Corliss engines direct connected to generators, an ice machine and the requisite auxiliaries.

Laundry for patients and staff is an important item in hospital operation and as the growth of the service required made the old facilities inadequate, two propositions were considered: To move the laundry combining it with that of the city workhouse where the labor cost would be small and waste heat from garbage incineration was available, hauling the hospital laundry in trucks; or to rehabilitate and reëquip the hospital laundry. Because of additional linen needed, delay and cost of hauling back and forth and extra cost for a new plant at the workhouse, rehabilitation was chosen and, in 1931, was put into effect.

Table I. Detail of Services for Heating and Non-Heating Seasons

	Distribution of Live Steam			
	Oct.1-May 23	May 24-Sep.30	Total for Year	%
Coal Used, t.	7,494.6	2,209.4	9,704.0	
Steam Gen'td., lb.	124,170,380.0	40,676,920.0	164,847,300.0	100.0
Kw. hr. Gen'td.	821,390.0	443,810.0	1,265,200.0	
Live Steam Used For				
Heating Bldgs., lb.	15,305,838.0	8,458,633.0	23,764,471.0	14.4
Added to Exh. "	50,103,529.0	-	50,103,529.0	30.4
Laundry "	7,692,884.0	4,307,116.0	12,000,000.0	9.2
Total for Htg. "	73,102,251.0	12,765,649.0	85,868,000.0	
Electric Pwr., lb.	34,744,797.0	18,772,503.0	53,517,300.0	32.5
Auxiliaries, lb.	13,399,000.0	7,501,000.0	20,900,000.0	12.7
Ice Mach., lb.	2,924,332.0	1,637,668.0	4,562,000.0	2.8
Total for Pwr., lb.	51,068,129.0	27,911,171.0	78,979,300.0	100.0

Temperature of water for house and laundry use was raised 120 deg. in the heating season and 105 deg. in summer. Hot water was circulated through a 2½-mile loop, the heat supplied to make up for radiation being included in cost of hot water heating.

Cost and Service Analysis

In reaching the decision, an analysis was made of costs for 1929 and of the laundry service required in 1930, with allowance for growth. Figures from power plant records for 1929 showed costs as follows:

Coal	52 per cent	$31,685.27
Labor	45 per cent	27,902.73
Supplies, etc.	3 per cent	2,163.80
Total		$61,751.80

Coal used was 19,408,000 lb. and steam generated 164,847,300 lb., an evaporation of 8.5 lb. steam per pound of coal. The cost of steam was $0.3746 per 1000 lb. Kilowatt-hours generated were 1,265,200 at a cost of $0.00372 per kw-hr.

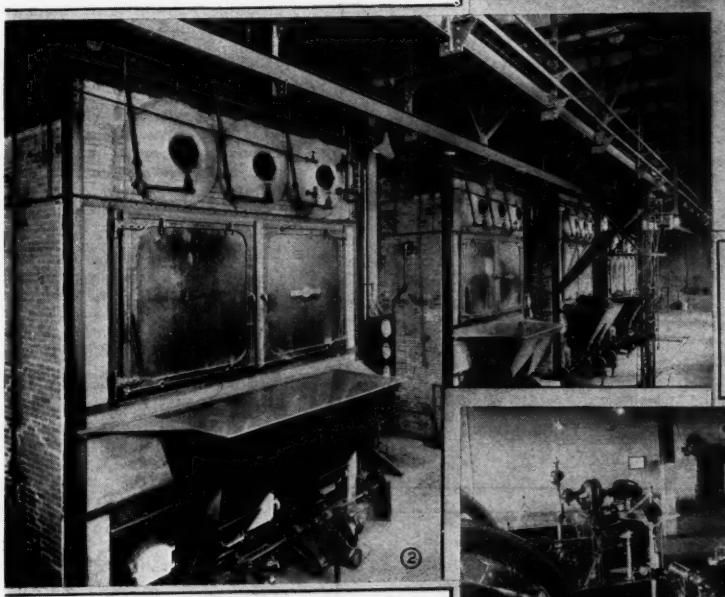
In studying operation, two periods were considered, the heating season from Oct. 1 to May 23, 234 days, and the non-heating season for the balance of the year, 131 days. Division of the steam used among services ren-

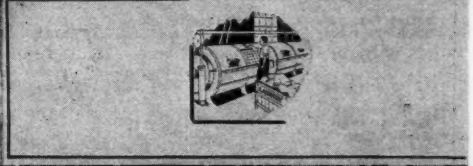
Table II. Disposal of Steam and Condensate

	Oct.1-May 23	May 24-Sep.30	Total	%
Heating Bldgs., lb. live and exhaust	61,081,862	-	61,081,862	37.0
Live steam drips, lb.	2,482,000	814,946	3,296,946	2.0
Domestic Hot Wtr. htg., lb.	20,901,521	7,582,861	28,484,382	17.3
Domes. Hot Wtr. Loop, lb.	3,621,174	1,571,665	5,192,839	3.1
L'dy. Hot Wtr. Htg., lb.	6,905,193	4,223,761	11,128,954	6.7
Make Up Wtr. Htg., lb.	3,956,802	2,573,304	6,530,106	4.0
Misc. Unaccounted	6,500,000	2,125,615	8,625,615	5.4
Ret'd. to Boiler, lb.	102,946,104	21,394,600	124,340,704	75.5
Cooking, Steril'z'g., lb.	16,519,460	7,245,011	23,764,471	14.4
Atmos. Ex., lb.	-	9,471,195	9,471,195	5.7
Ex. Drips to Sewer, lb.	4,704,816	2,566,114	7,270,930	4.4
Replaced in Make Up	21,224,276	19,282,320	40,506,596	24.5
	Water Heating			
House Use, lb.	160,974,892(120°)	70,080,081(105°)	231,054,973	
Laundry, lb.	55,840,000(120°)	39,060,000(105°)	94,900,000	
Boiler feed Make Up, lb.	22,454,276(171°)	19,977,078(125°)	42,431,354	

FIG. 1. NEW STAFF LAUNDRY, SOUTH VIEW

FIG. 2. BOILERS, STOKERS, GAGE BOARDS AND WEIGH LARRY





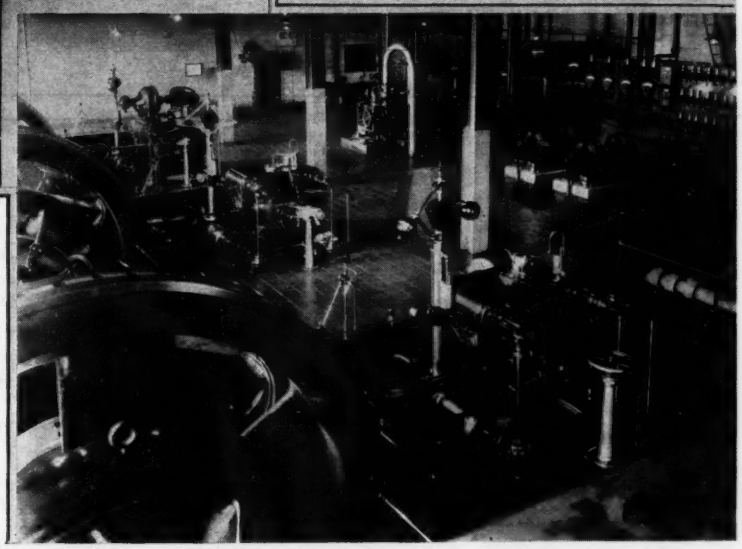


FIG. 3. ENGINE ROOM WITH AIR COMPRESSOR, EXCITERS AND SWITCHBOARD

dered was as shown in Table I. Disposal of steam in heating, cooking and exhaust was as in Table II, 75.5 per cent being returned to boiler feed, leaving 24.5 per cent make up water needed.

Auxiliary service included pumps for boiler feed and for hot water and brine circulation, also an air compressor, the net amounts of steam charged to them and costs being as follows:

Service	Per Cent	Lbs. Steam	Cost
Boiler Feed	50	1,987,302	$ 744.44
Hot Water	25	993,651	372.21
Brine	10	397,641	148.93
Air Compressor	15	596,191	223.31
Totals	100	3,974,605	$1488.89

Division of boiler feed pump costs among services is shown in Table III.

Analysis of power service costs of Table III shows that the steam chargeable to power and that available in exhaust for heating were as follows:

	Heating Season	Non-Heating	Year
Total Steam Supplied, lb.	51,067,839	27,911,461	78,979,300
Charged to Power—			
Elec. Power, lb.	3,474,414	8,483,651	11,958,065
Auxiliaries, lb.	937,926	2,736,295	3,674,221
Ice Mach., lb.	292,476	739,930	1,032,406
Total Charges	4,704,816	11,959,876	16,664,692
Bal. Ex. to Htg., lb.	46,363,023	15,951,585	62,314,608

The summary for various services is given in Table IV. Heating of buildings is by 122,021 sq. ft. of cast iron radiators and 20,104 sq. ft. of pipe coils. Allowing 180 B.t.u. per sq. ft. per hr. given out by radiators and 220 B.t.u. by coils the heating for 234 days or 5616 hr. at 26,386,600 B.t.u. per hour would require, if full service was needed for 40 per cent of the heating season, 61,081,862 lb. of steam. Hot water for house and laundry service were handled in the same system but have been separated in allocating charges.

Laundry service has increased steadily, having grown from 11,700 pieces daily in 1927 to 13,650 in 1931. Work

Table III. Steam Charge to Power Service

	Electric Power			Auxiliaries			Ice Machine		
Heating Season	%	Lb.	$	%	Lb.	$	%	Lb.	$
Initial Steam		34,744,137			13,398,940			2,924,762	
Chg'd.to Power	10	3,474,414*	1301.51	7	937,926*	351.35	10	292,476*	109.56
Non-Ht'g.Season									
Initial Steam		18,773,163			7,501,060			1,637,238	
Terminal Steam	90	16,895,847		93	6,975,896		90	1,473,514	
Ex. to Atmosphere		6,673,059			2,222,109			582,027	
Live Steam Equiv.	110	7,340,365*	2749.70	107	2,377,657*	890.67	110	640,230*	239.83
Bal. Initial Stm.		11,432,798			5,123,403			997,008	
% Bal. to Power	10	1,143,286*	428.27	7	358,638*	134.34	10	99,700*	37.34
Boiler Room									
Heat'g. Make Up		489,758*	183.46		300,384*	112.53		45,711*	17.12
Boiler Feed Pump		153,022*	57.32		-	-		13,911*	5.21
Brine Pumps		-	-		-	-		397,461*	148.93
Totals of * Items		12,600,839	4720.26		3,974,605	1488.89		1,489,489	557.99

Allocation Make Up Water and Boiler Feed Pump Costs

Boiler Feed M.Up 42,431,354 lb.water. Used 6,530,106 lb.steam. Cost $2446.18
Boiler Feed Pump Used 1,987,302 lb.steam. Cost 744.44

	Make Up Water Htg. Steam			Boiler Feed Pump Steam		
	%	Lb.	$	%	Lb.	$
Electric Power	7.5	489,758	183.46	7.7	153,022	57.32
Auxiliaries	4.6	300,384	112.53	-	-	-
Ice Machine	0.7	45,711	17.12	0.7	13,911	5.21
Htg. Bldgs.	38.7	2,527,828	946.67	39.6	786,972	294.80
Laundry Steam	7.4	483,228	181.02	7.7	153,022	57.32
Domest. Wt. Htg.	26.0	1,697,828	636.01	29.0	576,318	215.89
Cookg.Sterlz'g.etc.	15.1	986,046	369.37	15.3	304,057	113.90
	100.0	6,530,106	2446.18	100.0	1,987,302	744.44

Costs of power are shown in Table III, also allocation to various services of auxiliary costs and cost of heating and pumping boiler feed.

Table IV. Summary of Service Costs for Steam

	Charged Direct		Make Up Water		Feed Pump		Special		
	Lb.	Cost	Lb.	Cost	Lb.	Cost	Lb.	Cost	Total Cost
							Brine Pump		
Electric Power	11,958,065	$4,479.48	489,758	$183.46	153,022	$57.32	-	-	$ 4,720.26
Ice Machine	1,032,406	386.73	45,711	17.12	13,911	5.21	397,461	$148.93	557.99
Heating	61,081,862	22,881.27	2,527,151	946.67	786,972	294.80			24,122.74
							Circulating Pump		
							993,651	279.61	13,535.15
Domestic Ht.Wtr.	33,677,221	12,615.49	1,697,828	477.71	576,318	162.34	246,800	92.60	4,473.36
Laundry Ht.Wtr.	11,128,954	4,168.91	421,750	158.30	143,400	53.55	-	-	4,733.54
Laundry Steam	12,000,000	4,495.21	483,228	181.02	153,022	57.32	246,800	92.60	9,206.90
Total Laundry	23,128,954	8,664.12	904,978	339.32	296,422	110.87	-	-	9,385.47
Cookg.& Sterlz'g.	23,764,471	8,902.20	986,046	369.37	304,057	113.90			223.31
Air Compressor	596,191	223.31							

Costs in Table IV include the cost of auxiliaries, assigned to various fundamental services.

Table V. Laundry Equipment Selected

Patients' Laundry		Staff Laundry	
Washers			
Mammoth - 3 - 48x126", 675 lb. per run	= 2025 lb.	Cascade - 1 - 42x64, per run	= 225 lb.
Rylo - 1 - 42x 42", 105 " " "	= 105 "	" - 1 - 36x54, " "	= 125 "
Raytex - 1 - 25x 18", 20 " " "	= 20 "	Raytex - 1 - 25x36, " "	= 40 "
Steril - 1 - 36x 54", 120 " " "	= 120 "	Total per run	= 390 "
Total washing per run	= 2270 "		
Runs needed - 1½ hr. ea., 29 per week	= 43½ hr.	1½ hr. ea., 25 per week	= 43¾ hr.
Drying			
Extractors 2 - 54 in., 400 lb. per run	= 800 lb.	2 - 30", 80 lb. per run	= 160 lb.
1 - 30 " 80 " " "	= 80 "		
	880 "		
Runs needed, 30 min. ea., 71 per week	= 35½ hr.	30 min. ea., 61 per week	= 30½ hr.
Tumblers 1 - 44x94", 125 lb. per run	= 125 lb.	1 - 44x64, 85 lb. per run	= 85 lb.
Runs, 30 min. ea., 130 per week	= 43-1/3 hr.	30 min. ea., 24 per week	= 12 hr.
Ironing			
Roll Ironers 2, 8-roll, 120", 525 lb. hr. ea.	= 1050 lb.	1, 4-roll, 100", 210 lb. hr.	= 210 lb.
Runs for 45938 lb.	= 43½ hr.	For 6874 lb.	= 32¾ hr.
		3, 6 lb. per hr. ea. = 18 lb.	= 43½ hr.
		Presses for uniforms, 8% of staff work	= 785 lb.

This new equipment was selected to handle 65,625 lb. a week for 1100 patients and 9820 lb. a week for a staff of 535 women and 95 men.

is usually figured by weight rather than pieces and the survey in 1930 showed work handled in the 44-hr. week of 52,500 lb. for patients, which with 25 per cent allowance for growth gave 65,625 lb. a week to be provided for.

Work for the patients and staff is separated: For each employe, 3 lb. of bed linen a week are needed and study of requirements showed 10 lb. a week of personal laundry for women and 6.5 lb. for men, or totals of 13 and 9.5 lb. respectively. For the 535 women and 95 men on the staff, this totaled to 7855 lb. a week, which with 25 per cent allowance, gave 9820 lb. to be provided for.

To care for these amounts the equipment in Table V was recommended.

Of the laundry, 70 per cent is flat work, requiring ironing after extraction drying, the balance is rough-dry, finished in tumblers. For the patients' side, the flat work would be 45,938 lb. and for the staff side 6874 lb. a week; rough-dry would be 16,406 and 1964 lb. respectively.

Check Up on Laundry Power Costs

During 1930, Mr. Fette made a check on costs for laundry power which involved some ingenious calculations. A 6-day test showed an average from flowmeter of 514 hp. for 11-hr. day load, 391 hp. for 13-hr. night load and 386 hp. for Sunday 24-hr. load. The laundry did not run nights or Sundays.

For week-days the average horsepower-hours were, $514 \times 11 + 391 \times 13 = 10{,}737$. For Sunday, they were $386 \times 24 = 8264$. The difference was 2473 hp-hr., or an average of 103 hp. for the 24-hr. day, due to laundry load. Difference between week day and week night load was $514 - 391 = 123$ hp. $103 \div 123 = 0.837$ or 83.7 per cent of the week day load excess over Sunday load was due to the laundry.

Tests showed 17.15 t. coal average per week day and 14.45 t. for Sunday, a difference of 2.7 t., of which 83.7 per cent, or 2.26 t., would be for the laundry.

At $3.83 a ton, this is $8.65 a day, or for the 307 days the laundry works, $2665.55. Records showed that coal cost was 52 per cent of total operating cost, hence $2665.55 \div 0.52 = \$5106.83$ would be the yearly live steam cost for the laundry.

Four months check showed the average daily electric load as 4146 kw-hr. and the average Sunday load as 3224 kw-hr., a difference of 922 kw-hr. Of this, 83.7 per cent was charged to laundry, or 772 kw-hr. For 307 days and at the cost of $0.00372 per kw-hr. established from 1929 records, this gives $307 \times 772 \times 0.00372 = \$881.32$ as yearly electric cost.

Hot water for laundry use was not metered separately but the average for the year was 10,330 cu. ft. a day while the average difference between week days and Sundays was 3336 cu. ft., which can be assigned to the laundry. Laundry water was, therefore, 32.3 per cent of the total.

Besides the domestic water, boiler make up water was heated, this being 15.5 per cent of the total heated. Cost for heating water in 1930 was $13,135.44, of which 84.5 per cent was for domestic and laundry, or $11,099.45 and 32.3 per cent of this is $3585.12, the cost for heating laundry water.

Summarizing the costs for laundry power and heat gives values in the first column:

	1931	1932
Live steam cost	$5106.83	$3017.81
Electric power cost	881.32	361.85
Hot water cost	3585.12	3020.88
Total	$9573.27	$6400.54

In comparison a week's test during 1932 has shown the yearly cost to be as in the second column. The lower cost for electricity would indicate that earlier estimates of cost per kilowatt-hour were too high.

Installation of a heat reclaimer for extracting heat from the wash water has also shown savings. First cost of the equipment was $1915 and of installation $800, a total of $2715. Yearly saving shown is $911.42 or a return of 33½ per cent of the cost each year.

Assure Clean Dry Steam

By W. F. Schaphorst

For turbine, engine, and other uses clean steam is essential in these days of high steam velocity, high temperatures, and high pressures.

Where steam is not clean we commonly find deposits of scale or dirt in engine cylinders and on turbine blades. Sodium sulphate, dirt, and calcium carbonate are the principal offenders. Not only do the impurities clog but they cause damage by cutting turbine blades and valve discs, making traps and valves inoperable, ruining engine cylinders, etc.

To avoid these troubles one of the simplest methods is the installation of a steam separator. The function of the separator is to eliminate moisture. By getting rid of moisture all dirt is eliminated also, because it is only the water in steam that carries over the impurities. Dry steam cannot carry scaling impurities.

Furthermore if steam is dry there can be no dangerous slugs of water. Slugs of water, as from foaming, priming or condensation in the pipe lines, frequently strip blades in turbines and are almost invariably destructive to reciprocating engines. Cylinder heads are frequently blown off or broken, studs stripped of their threads or pulled apart, cylinders cracked, piston rods, cranks, connecting rods and frames twisted, bent or broken, etc.

Although separators are installed principally to make steam dry and clean, there is also a thermal saving involved. This saving is sometimes small and sometimes it amounts to a great deal. By removing all moisture, superheat can be increased. Hence from a heat standpoint, when using superheated steam, one can count on an increase of about 17 deg. to every 1 per cent of moisture removed. A rule sometimes used is that "each pound of water entails the consumption of an additional pound of steam to produce the same power."

Some turbine manufacturers give the reduction in steam turbine water rate of 1 per cent for every 12 deg. increase in superheat. If 2 per cent of moisture is removed the superheat would therefore increase 34 deg., which would be equivalent to almost 3 per cent reduction in turbine water rate. One can easily figure for himself what this amounts to during an entire year.

POWER PLANT ENGINEERING March 1933

This thing called POWER FACTOR——

Part V. The effect of a condenser upon an inductive circuit excited by an alternating e.m.f. Reactive current. Location of a condenser in the circuit to correct power factor.

SO YOU'RE back again, are you?" exclaimed the Chief Engineer as Val came in the door and parked himself in the chair opposite the chief's desk,—"where'd you get the cigar?"

"Over in Newark last night; here, try one, they're much closer to tobacco than the hay you smoke."

"Over in Newark again, eh?" So that's where you've been hanging around—thought I'd missed your refreshing presence around these parts. But remember, you can't mix Pink Ladies or whatever you guzzle over in Newark with power factor——"

"Oh yeah?" exclaimed Val. "Well, never mind the insinuations, big boy—I want you to understand that my trips to Newark are always strictly on business. As for power factor, well, that's what I'm here for now—you're going to continue where you left off last week. Furthermore, I'm all fed up on your talking about direct current, springs, flywheels and what nots. I know all about those things now. From here on give me some dope on alternating current—no more monkey business."

"Wow, what an ultimatum," exclaimed the engineer throwing up his hands in mock defence. "My Gosh! one would think you were paying for this course instead of just being a victim of charity and my good nature. But I suppose you must be humored. Let's see, where did we leave off last time?"

"You showed me why a condenser in a direct current circuit could counteract the effect of inductance when the circuit was closed."

"Oh yes, to be sure—and you understand all that perfectly, do you?"

"So much so that I can almost tell you what happens in an alternating current circuit. I've got it all figured out——"

"All right," said the chief, "that's fine—suppose you do that, explain it to me."

"Oh, well, I didn't mean it that way, but I have an idea that in an alternating current circuit the action is very much the same. There, the electromotive force is not constant—at one time it is building up, at another time it is decreasing and at regular intervals reverses its direction. Now. I figure the thing out in this way—when the e.m.f. is building up, the condition is the same as in the direct current circuit when the switch is first closed and the current which flows charges the condenser. Then when the e.m.f. decreases, the current flows out of the condenser through the inductance. Isn't that right?"

"Yes, partly," replied the engineer, "not entirely, but you get the fundamental idea, I think. Let's look at it another way. Suppose we have an alternating current generator, connected to an inductive circuit as shown in this diagram (Fig. 1). In this instance as you have explained, the impressed voltage is continually varying. When it is increasing, the energy supplied by the alternator is expended, not only in overcoming resistance but also in establishing a magnetic field around the conductors. This building up of the field manifests itself in the production of a counter electromotive force as you already know. When the e.m.f. of the alternator is decreasing, however, the energy which is stored in the magnetic field is given back to the circuit in the form of an electromotive force which tends

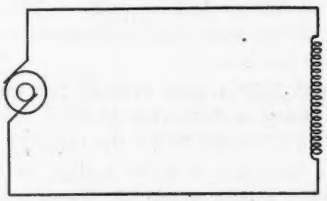


FIG. 1. A SIMPLE INDUCTIVE CIRCUIT CONTAINING A SOURCE OF ALTERNATING E.M.F.

to maintain the current—that is, it tends to keep it from decreasing. You understand all this, of course."

"Sure—our old friend the flywheel effect, I get yah. It's the same as it was in the direct current condition, except that here the impressed voltage is varying all the time and so the counter electromotive force also is continually present and acting in opposition to the impressed e.m.f."

"You don't really mean the *impressed* e.m.f., do you?" interrupted the engineer.

"No," said Val, I don't mean that—I mean the *active* e.m.f. That is, the counter e.m.f. is continually acting in opposition to the active e.m.f. rather than the impressed e.m.f."

"Good, despite the fact that you're only a chemist, you seem to grasp the idea. Now, this interchange of energy between the alternator and the inductance is not accomplishing anything, is it? I mean, it's doing no useful work. It is true, the energy given to the magnetic field at one instant is returned to the alternator the next. One instant it exists as a magnetic field surrounding the inductance, at the next it appears as e.m.f. in

the circuit which tends to oppose the e.m.f. of the generator."

"The same as in the flywheel," interposed Val.

"Yes, exactly," agreed the engineer. "In the case of the flywheel, you recall, a large part of the acting force was expended in merely overcoming the inertia of the moving mass. There again, the energy given to the system at one part of the stroke was returned to it at the next, but because of this periodic interchange of energy a stronger connecting rod was required.

"And so also, in this instance, for a given amount of useful work done in the circuit, larger conductors are required to carry the current than would be required if the current and e.m.f. of the generator were in phase with each other. That energy which thus surges back and forth between the generator and the inductance does not register on the kilowatt-hour meter. The meter only registers that current which is converted into heat or if there is a motor, into mechanical energy in the motor.

"Now, of course, as I told you once before, there can be only one current in any electrical circuit at one time, but for purposes of convenience in calculation, the energy which surges back and forth in this manner without doing any useful work is called the reactive current, or reactive power, and that energy which is not returned to the alternator, the power current, or useful

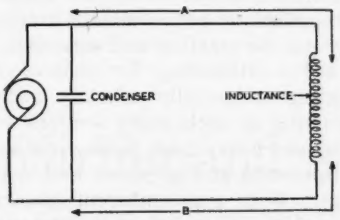


FIG. 2. A CONDENSER PLACED AS SHOWN IN THIS DIAGRAM DOES NOT RELIEVE THE LINE OF CARRYING THE REACTIVE CURRENT

power. The reactive current is also spoken of as wattless current."

"But you say only one current exists?" said Val.

"Absolutely, but as I pointed out before, any force can be considered as being made up of two or more components, and so it is in this case. We merely consider the current or power, or electromotive force in the circuit as being made up of 'reactive' and 'power' components, but these are purely imaginary conceptions.

"Now, let's go back to the flywheel for an instant. There, as you will remember, we placed a spring on the shaft which neutralized the effect of inertia of the wheel and thus made possible a smaller connecting rod. So in this case, we do the same thing—we put a spring, that is a condenser, in the circuit which will neutralize the effect of inductance."

"Where do you put it?" interrupted the chemist.

"Where do you suppose?" countered the chief.

Val studied the diagram again.

"Well, across the inductance, I suppose," he said, "just as in the direct current circuit."

"Yes, but that's not all," insisted the chief. "It must be placed as close as possible to the inductance or motor, or whatever it is you have in the circuit."

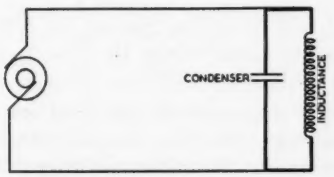


FIG. 3. THE CONDENSER MUST BE PLACED CLOSE TO THE INDUCTANCE AS SHOWN HERE. THE REACTIVE CURRENT THUS IS CONFINED TO THE PORTION OF THE CIRCUIT SHOWN BY THE HEAVY LINES

"Why is that?" asked the chemist, "isn't the effect of the condenser the same, regardless of whether you put it close to the inductance or far away from it?"

"Yes, of course, but that's not what concerns us here. What are we trying to accomplish?"

"Neutralize the effect of inductance, of course," replied Val impatiently.

"Is that all?"

"Yes, isn't it?" asked Val, timidly.

"No, of course not, you poor dumbbell," said the engineer with feigned contempt. "What did you come here for in the first place? We're trying to correct power factor, aren't we?"

"Oh, of course, I know that—why didn't you say what you meant——"

"All right then," continued the engineer. "We're trying to correct power factor which means getting rid of that 'useless' or 'wattless' current surging between the inductance and the alternating current generator. We know that we can do this by means of a condenser, now, where shall we place this condenser? Suppose we put it close to the generator as I have shown here (Fig. 2). Would that help any? Before we answer this let us see again what happens when the condenser is connected to the line.

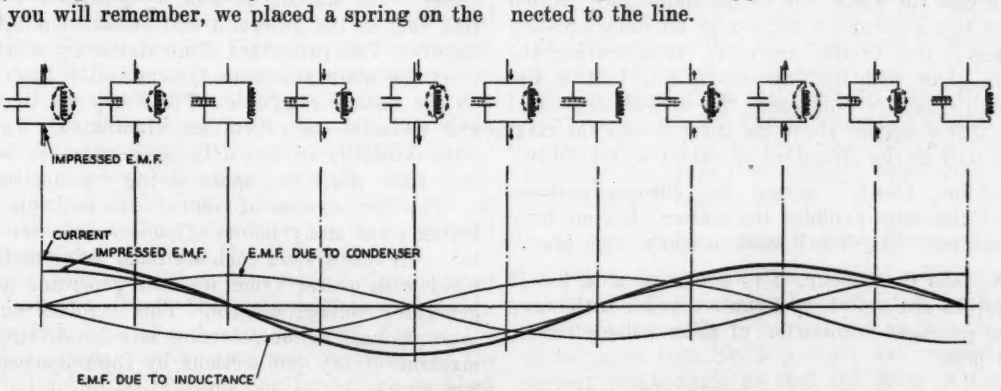


FIG. 4. A DIAGRAM SHOWING THE VARIOUS E.M.F.'S AND CURRENTS AND THEIR RELATIONS IN AN A.C. CIRCUIT IN WHICH THE INDUCTANCE IS PROPERLY NEUTRALIZED BY A CONDENSER

"Before the condenser was connected, we know there was a 'reactive' current surging back and forth between the inductance and the generator. Now, with the condenser in the circuit the condition is very similar, except that now the 'reactive' current surges back and forth between the inductance and the condenser. At one instant the energy exists in the form of an electromagnetic field of force surrounding the inductance, at the next as an electrostatic field between the plates of the condenser.

"Since this is the case, our placing the condenser as shown in Fig. 2 is not helping matters any for the conductors A and B must still carry the reactive current in addition to the useful current."

"I see," said Val, "by placing the condenser close to the inductance you relieve the line of the necessity of carrying the reactive current."

"Exactly," responded the chief. "Here, let me draw another diagram (Fig. 3). In this the condenser is placed close to the inductance. The condition is still the same except that with the exception of that small portion of the line between the inductance and the condenser and the inductance, which I have shown heavy, the line has been relieved of the necessity of carrying the reactive current."

"Say, Chief, that's great," exclaimed Val. "I see it all now. It's the same as the flywheel and the spring. There the addition of the spring relieved the force applied to the connecting rod from the necessity of overcoming the inertia of the wheel at each stroke while here the condenser relieves the alternator from overcoming the necessity of supplying the reactive current. Isn't that right?"

"Yes, that's correct," assented the chief engineer, "but I want you to get this also. The electromagnetic field corresponds to the kinetic energy of motion of the flywheel while the electrostatic field in the condenser is equivalent to the potential energy stored in the spring. Just as the kinetic energy of the flywheel has significance only when the wheel is in motion, so the counter e.m.f. of self inductance only has significance when the applied e.m.f. (of the alternator) is actually charging.

"Now let's go back to the wave diagram[1] which I drew in explaining the effect of the spring on the flywheel. Just take another look at it and then look at this one (Fig. 4) which I have just drawn showing the electrical condition. You see how similar they are. Also note how the e.m.f. due to the inductance (which ordinarily is the counter e.m.f.) is at all times opposed by the e.m.f. due to the condenser, thus leaving the current in phase with the impressed e.m.f. In this diagram, as in the previous ones, the arrows associated with the little diagrams above the curve denote the magnitude as well as the directions of currents and fields."

"Yes, fine, Chief," agreed the chemist enthusiastically, "that sure explains the matter. Let me have these diagrams, will you? I want to study them over."

"Sure, take them along. I've got to go now, but if you'll drop in again perhaps I can tell you a little more about the practical application of these principles. So long, old man."

[1]Fig. 7—page 819—December 1932 issue.

Present Practice in Sectional Paper Machine Drives*

Due to the steady development in electric drive systems, the scope of the paper machine has been greatly extended in recent years. The most recent refinement is the application of Selsyn control to paper machine drives.

By
R. H. ROGERS Industrial Eng. Dept. General Electric Co.

SECTIONAL MOTOR drive for paper machines to a large extent has superseded mechanical drive and made the modern wide, high-speed machine possible. The paper machine in recent years has become more highly developed, refinements have been added and the manufacturing scope of a single machine has been greatly extended. These changes have put more burdens on the electric drive but in every case, the desires of the machine and the paper manufacturer have been met.

The normal, and for years, the only method of operating sectional drives was by the use of a single generator utilizing adjustable voltage for the general speed control of the machine and rheostatic control of the individual sections for starting and servicing. This method was and still is satisfactory for moderate speed ranges and is operating successfully on many machines. However, the starting of such heavy sections as driers and calenders imposes heavy peak loads especially when the machine is operating at high speed and consequently at high voltage. With good inherent generator voltage regulation and regulator, these peaks are not objectionable.

In order to give a paper machine wide latitude in its field of production, there came a demand for drives and control good for ten-to-one speed change so that one machine would be able to meet paper-market demands with a great variety of sizes of paper.

Auxiliary starting generator equipment was adopted to some extent to overcome the objections to rheostatic starting on wide speed range machines. For this type of drive a separate generator is provided for starting duty only and each section is brought up to speed by itself and is then transferred to the main driving generator. The starting is done by generator voltage control, that is, the generator and motor come up to speed together. This procedure eliminates heavy starting loads from the main generator system and reduces the duty on the voltage regulator. The heavy starting resistors and sectional controllers are eliminated. This system lacks flexibility in that only one section can be serviced at a time. Expected space saving was not realized.

The third system of control—the multiple generator system—has many points of superiority over the other two. In this system each sectional drive motor is supplied with power from its own generator and under generator voltage control. This involves one or two multiple unit motor-generator sets for driving a paper machine of say ten sections by interchangeable units.

*A paper delivered at the International Electrical Congress, Paris, July 1932.

This is the utmost flexibility of control available since any or all sections can be independently started, stopped, jogged, run at slow or full speed at the same time. Generator voltage control eliminates large controllers, contactors, and resistors for the motors. Speed control and the close regulation is effected at the generator field so that a strong motor field is always available for good torque and stability characteristics. The torque efficiency being constant (especially advantageous at low speed), smaller motors can be used. The total space required is no more than for either the first or second system since space required by the multiple unit sets is saved in control devices.

While a speed range of ten-to-one covers the requirements of most paper machines there is an occasional demand for more—such as thirty-to-one on small paper machines. Obviously close speed regulation, i.e., voltage regulation over such a wide range, for instance, 300 to 10 v., would be impossible. These small machines are normally driven by a single motor where the speed range is normal. Thirty-to-one range is met by the use of two motors, the larger operating the machine from top speed down to one-sixth speed. The second motor is geared through a five-to-one gear unit to the shaft of the larger motor. For low speeds, power from the d-c. generator is transferred from the large to the small motor which then also has a six-to-one speed range with maximum speed one-fifth the maximum speed of the larger motor. Thus there is an overlapping of speeds at the transfer point.

Selsyn Control

A notable feature of the most modern sectional paper machine drive is the Selsyn control of speed regulation and "draw" between sections. Selsyns are self-synchronizing units and may be masters, followers, or differentials. A master Selsyn is driven by power, a follower faithfully follows its rotations or fractions.

The application to sectional drive is simple. A master Selsyn is driven at a constant speed by a motor. Each sectional motor drives a master. Between the sectional masters and the constant speed master circuit are connected differential Selsyns. Should the sectional drive motor slow down or speed up, the differential Selsyn readjusts the field to counteract the change. An adjustable speed feature is incorporated in the drive between the sectional motor and its master Selsyn so that the section can be made to run a little faster or slower as required to maintain safely the weak web of paper between sections. This so called draw adjustment is made from the front of each section. An interesting refinement is the further use of Selsyns here. A hand wheel is attached to a master Selsyn on the front of the section and a follower serves to move a belt on a pair of cone pulleys in the adjustable speed Selsyn drive at the back. When the hand wheel is turned ever so small an amount, the follower shifts the belt on the cones by a corresponding amount and the section speed is changed by perhaps one-tenth of one percent, but this would be 1.2 feet per minute when paper is being made at 1200 feet per minute.

Repairing and Alining Diesel Engine Shafts

No Machine Can Be Expected to Operate Satisfactorily Unless It Is Properly Erected. By J. J. McDougall

EACH YEAR sees the field of the Diesel engine broadened in spite of the flagrant abuses to which many of them are subjected. Often an engine, apparently giving trouble from many different causes, can be quickly straightened out after a few simple adjustments by an expert. Generalizations are difficult to make but the following actual case shows what difficulties may arise from faulty crankshaft alinement.

In the case of this 1700-hp. engine, continuous troubles were experienced from the time the engine was put in service until the shaft was correctly alined. The most important of these difficulties were: hot and finally squeezed out journal bearings; thrust bearings running hot; failure of link-belt driving exciter; the breaking of the shaft through No. 8 journal and the breaking of the shaft through No. 2 crank-pin. When the engine was first started the most noticeable feature was that the flywheel did not run true, having a slight wobble and a distinct jump. This was protested as being unsafe but nothing was done to correct it until after a few weeks' operation No. 8 journal broke.

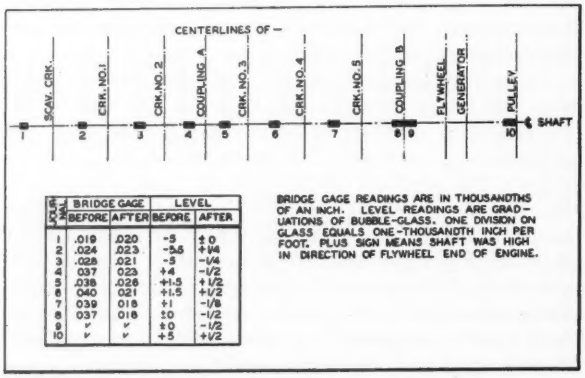
This was replaced without removing the crank-shaft from the engine. First, the section of shaft between couplings A and B, Fig. 1, was stripped, that is, the pistons and journal bearing caps were removed and the shaft lifted out of its bearings and leveled up on block of such height that the coupling flanges would clear each other. Then the broken journal was pressed out with a hydraulic jack, placed between No. 5 crank-webs. In order to avoid springing the web, the web around the broken journal was slightly heated so that it required only a few tons pressure to remove the broken part. Then a new journal was pressed in, allowing about 0.00075 in. per in. of diameter for the press fit, the shaft being pressed in at about 175 t. The shaft was roughly checked over and the engine put back in service.

After a few weeks, during which troubles continuously increased, No. 2 crank-pin broke. The new engineer pointed out that the records, as marked on Fig. 1, as taken off the shaft alinement showed distinctly that the alinement of the shaft was poor and the best thing would be to aline it within reasonable limits. As shown in the table of Fig. 1, there was a difference of 0.021 in. between Nos. 1 and 6 bearings, when 0.005 in. would be considered reasonable.

Replacing Broken Crank

The broken crank was replaced without taking the shaft out of the engine by using the same system as when replacing No. 8 journal, but in this case care had to be taken that No. 5 journal was pressed in at the correct crank angle so that the holes in the coupling would line up correctly. The other crank-web, also, must

be pressed on to No. 4 journal so as to correctly line up with No. 1 crank. Figure 2 shows the method used in this case. Levels showed that the bedplate had been correctly levelled, and checking with the bridge gage and micrometer showed that the bearing pedestals had been accurately machined. The fault therefore lay in the fitting of the bearings to the shaft.



JOURNAL	BRIDGE GAGE BEFORE	BRIDGE GAGE AFTER	LEVEL BEFORE	LEVEL AFTER
1	.019	.020	-5	±0
2	.024	.023	-3.5	+1/4
3	.028	.021	-3	-1/4
4	.037	.023	+4	-1/2
5	.038	.026	+1.5	+1/2
6	.040	.021	+1.5	+1/2
7	.039	.018	+1	-1/8
8	.037	.018	±0	-1/2
9	"	"	±0	-1/2
10	"	"	+5	+1/2

BRIDGE GAGE READINGS ARE IN THOUSANDTHS OF AN INCH. LEVEL READINGS ARE GRADUATIONS OF BUBBLE-GLASS. ONE DIVISION ON GLASS EQUALS ONE-THOUSANDTH INCH PER FOOT. PLUS SIGN MEANS SHAFT WAS HIGH IN DIRECTION OF FLYWHEEL END OF ENGINE.

FIG. 1. ALINEMENT OF SHAFT BEFORE AND AFTER ADJUSTMENTS

Bottom shells of the journals were found in such condition as to require rebabbitting but the top shells were in good condition. In order to do the job quickly and accurately, a cradle was made out of boiler plate and angle-iron and bolted to the lathe carriage, carefully dowelled for future use, and then bored out to the standard outside diameter of the bearing shells. While checking these shells No. 9 shell was found to be about 0.030 in. undersize and was replaced with a spare of correct size.

Since there was several thousandths of an inch variation in the diameter of the journals, each shell was bored out to the diameter of its journal plus 0.006 in. After spotting and scraping, the alinement checked as in Fig. 1. For slow speed work, one division of the level and 0.003 in. on the bridge gage had given satisfactory service, and in this case due to the variation in the diameters of the journals 0.008 in. was not considered excessive on the bridge gage. As a check, the couplings lined up perfectly and after bolting them up and adjusting the journal bearings to 0.010 in. clearance, the shaft turned freely. When put back in service, the performance was satisfactory and the flywheel ran true.

Interpreting Reading

From the readings in the table of Fig. 1, the reasons of the shaft breaking at No. 2 crank are evident, for the bridge gauge shows a sharp drop from journal No. 3 to No. 4. The level shows that the shaft changes from —5 to +4 between these bearings so that at No. 2 crank there was a decided bending strain in No. 2 crank-pin. Reasons for the breaking of No. 8 journal seem to be indicated by the fact that No. 9 journal showed no evidence of carrying its share of the fly-wheel and generator loads while the babbit of No. 8 was squeezed although not dragged or burnt. This squeezing forced the thrust ring against the coupling B and caused trouble with that thrust bearing formed of bronze rings fitted to the ends of Nos. 8 and 9 journals.

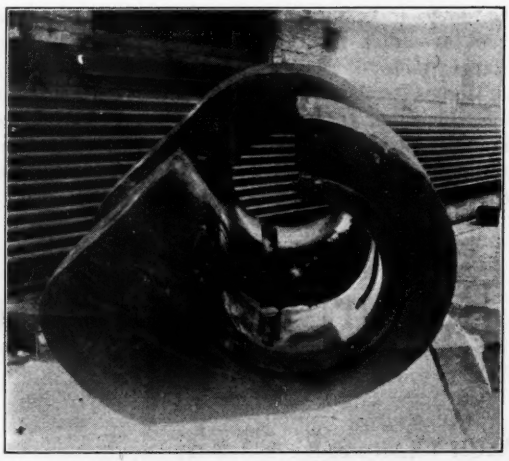


FIG. 3. DOWEL HOLES MENTIONED IN FIG. 2

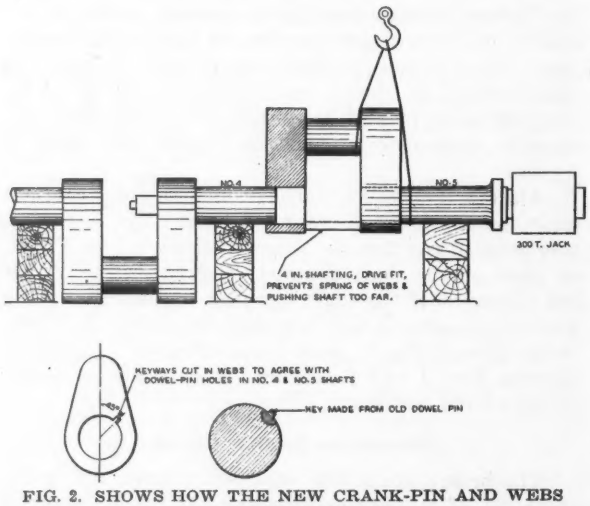

NO. 4
NO. 5
300 T. JACK
4 IN. SHAFTING, DRIVE FIT, PREVENTS SPRING OF WEBS & PUSHING SHAFT TOO FAR.
KEYWAYS CUT IN WEBS TO AGREE WITH DOWEL-PIN HOLES IN NO. 4 & NO. 5 SHAFTS
KEY MADE FROM OLD DOWEL PIN

FIG. 2. SHOWS HOW THE NEW CRANK-PIN AND WEBS WERE PRESSED ON

The webs were fixed at the correct crank angle by using the old dowel pins and cutting a key-way in the webs to agree with the dowels in the broken crank webs. In this case the angle was forty-five degrees with a line drawn through the center of the crank-pin and journal. This key also prevented the shafts or journals from twisting as they were being pressed on as sometimes happens when no key is used.

Bridge gage is of no use on these bearings but the level showed that No. 10 was high and had to be lowered about 0.060 in. to bring the shaft level. This explains failure of the exciter chain drive and its continual attempt to climb off its pulley. It can be seen that No. 8 bearing was over-loaded and this, plus the vibration due to the whipping action of the shaft, flywheel and generator, caused the journal to break.

As two other engines had shafts fail at the same place under similar conditions, it would appear that too much care cannot be taken to keep the shaft in proper alinement. On one occasion, a flywheel was blamed for the shaft failure. Several thousand dollars was spent trying to machine the wheel and adjust it with shimming and shrinking so that it would run true on a shaft that did not run true. When the bearings were finally adjusted correctly the flywheel actually does wobble because it is no longer symmetrical.

Readers' Conference

Motor Maintenance

AT ONE TIME WE HAD considerable trouble with motors buring out, being hard to start, having hot bearings and about every other known motor disease. As we had over two hundred motors throughout the plant this was a serious and expensive state of affairs. The electrician blamed the millwright, the millwright blamed the machine operator and the machine operator alibied he was not an electrician. Men were "jacked up", switched and fired but the motor trouble stayed right with us. Finally the Chief Engineer took a very definite step.

First he selected a middle aged, thorough going, conscientious man who had been in the millwright gang for many years and who also had a good practical knowledge of motors. This man—Tom was his name—was given full charge of all motors, that is; all motor troubles were turned over to him and he was held fully responsible for motor maintenance costs. His hours were then scheduled different from the other men and he was told to work from eight in the morning to six in the evening with a dinner hour from one thirty to two thirty. This arrangement, you will notice, gave him two hours every day—except Saturday—during which practically all the motors were shut down and thus enabled him to examine bearings, measure air gaps, check starter and do similar things that can only be done when the motor is "dead".

Tom was left alone for a week to accustom himself to his new job and become familiar with the location of the various motors throughout the plant and then he was given the following routine instructions:

(1) See that every motor, that is operating in a dusty place, is blown off at least once per week.

(2) See that all bearings have ample lubrication.

(3) Check up gap between rotor and stator and if this is below standard space it must be immediately reported to the master mechanic in writing so new bearings can be promptly installed.

(4) Drain and clean all plain bearings at least every thirty days and refill with clean oil. Ball bearings must be taken down and cleaned at least once per year. The oil that is drained out of bearings is to be salvaged through an oil filter.

(5) See that motor is in good mechanical running condition, also that pulley or gear is tight on shaft.

(6) Look over starting equipment and see that knife blades are clean and smooth also, if of the compensator type, see that clean oil is in reservoir and contacts are clean and smooth.

(7) Test fuses and see that they are of proper amperage for motor they are supplying. If time limit relays are used, test same out and see that they are in first class working condition; also see they are set to proper amperage.

(8) Look over motor connections and be sure they are in accordance with the Underwriter's requirements.

(9) Check amperes per terminal and all unloaded or overloaded motors to be changed.

(10) Make out daily report of motors cleaned and ok'd the previous day and send to master mechanic.

Within 6 weeks practically all motor troubles vanished and, to everyone's content, motor maintenace costs fell to a record low and then stayed there. Tom proved to be of a systematic disposition and kept a small 3 x 5 card record of the condition of every motor in the plant and also learned how to make insulation resistance tests so motors could be changed conveniently for rewinding before actual breakdown occurred. In other words: Tom made the scheme a huge success.

Moline, Illinois. GEO. P. PEARCE.

Cooperation Between Private Plants and the Utilities

THE ARTICLES by Mr. O. H. Henschel in the February 15, March 15, April 15, and July 15, 1932 issues are very interesting in showing the possible saving to industrial plants by generating that part of their power which corresponds to their heating and process steam demands.

That there is a very real saving to be effected by this method has been recognized for some time but the difficulty has often been to present the case to the Utilities in such a way that they would feel justified in furnishing the balance of the power required at rates and under conditions that make the method practicable. For this reason it is particularly important in presenting a case to the Utilities that there be no inconsistencies in the calculations which they can point out and use as a reason for discarding the whole scheme.

In the case of the toy factory first considered there are several assumptions made which cannot be justified and would certainly hurt the presentation of the case. First: It is assumed no additional fuel will be required because of passing the steam through a turbine and extracting power from it. No data is given as to the pressure and condition of the steam from the boilers or the back pressure required for heating and process steam. From the water rates given it is probable that the boiler pressure is about 150 lb. gage, the steam nominally dry and saturated, and the back pressure 10 lb. gage. A water rate of 66 lb. per kw-hr. means that about 52 B.t.u. are taken from each pound of steam passed through the turbine and if the feed water enters the boiler at about 180 deg. F. this represents about 5 per cent of the total heat supplied to each pound of steam and would increase the fuel required to produce the steam by that amount. Second: The water rate of the turbine is assumed to be the same at partial loads as at full load while all commercial turbines of this type take at least 20 per cent of steam used at full load to run the turbine up to speed at no load. This would mean that in the two semi-heating months when 3500 lb. of steam per hr. is available only about 40 kw. could be generated instead of 53 kw. as assumed and that during the non-heating months no power could be generated as there is not even enough steam available to run the turbine up to speed.

With these corrections Mr. Henschel's table as given on page 256 of the March 15 issue becomes as follows:

Month	Fuel Cost	Purchased Energy Costs	Total Costs
January	$ 672.00	$ 391.59	$ 1,063.59
February	672.00	391.59	1,063.59
March	672.00	391.59	1,063.59
April	364.00	529.98	893.98
May	112.00	622.25	734.25
June	112.00	622.25	734.25
July	112.00	622.25	734.25
August	112.00	622.25	734.25
September	364.00	529.98	893.98
October	672.00	391.59	1,063.59
November	672.00	391.59	1,063.59
December	672.00	391.59	1,063.59
Total	$5,208.00	$5,898.50	$11,106.50

and the yearly cost including fixed charges

Fuel	$ 5,208.00
Purchased Energy	5,898.50
Fixed Charges	703.00
Total	$11,809.50

Which gives a cost per kw-hr. = $0.0289.

Third: There is at least an apparent inconsistency in crediting the sale of old equipment to the investment cost in this case, and not in the cases of all purchased energy and all generated energy.

Of course, the same type of correction should be applied to the case of the 125 kw. machine having a water rate of 52 lb. per kw-hr. and will make the yearly cost as follows:

Fixed Charges	$ 1,093.35
Fuel	5,248.00
Purchased Energy	5,529.34
Total	$11,870.69

Which gives a cost per kw-hr. of $0.0291.

Another point that should be considered is that if a 250 kw. machine that could be installed for about $10,000.00 were used and the same rate of depreciation figured as for the 100 kw. unit this would show a cost for generating all power that would compare favorably with the lowest cost shown.

In the case of the furniture factory taken up in the last two articles the case is somewhat different. Here again the heat equivalent of the power generated is entirely neglected, although it must amount to at least $250.00 per year in the case of complete generation. However, the thing that appears hardest to explain is how 89,195 kw-hr. per year with monthly quantities ranging from 0 to 11,600 kw-hr. can be purchased at the same average cost per kw-hr. as 202,900 kw-hr. per year with monthly quantities ranging from 13,700 kw-hr. to 21,800 kw-hr. If a rate similar to that used in the previous articles on the toy factory were used here, the cost per kw-hr. would be at least $0.03, which appears much more reasonable, although it would increase the cost of purchased current by about $625.00 and reduce the expected saving to $750.00 if the added fuel cost is not considered or $600.00 if this item is considered.

Have recently investigated several plants in which either the partial or total generation of the power required was under consideration and find that in most cases it is necessary to make up daily load curves of steam and power required before a satisfactory estimate of the steam available for power generation can be made as in many plants the maximum demands for steam and power do not occur at the same time. Where this happens it means that considerable exhaust steam is wasted during certain parts of the day and that at other times live steam has to be used for heat and process, thus materially increasing the total steam required. Unless all of the above factors are carefully considered the estimated savings may prove much too high and the results of the installation disappointing.

I have found that the Utilities are usually ready to cooperate with their customers where a complete investigation has been made and a conservative estimate shows that substantial savings can be made by partial generation of power provided the installation can be made in a way that will not reduce the reliability of their service to their other customers. On the other hand if an estimate is presented which neglects any important item or which is apparently too optimistic, they naturally are inclined to feel that it is just another attempt to force down their rates and treat it as such.

WILLIAM W. GAYLORD,
New Haven, Connecticut. Consulting Engineer.

Painting Steel Work

IN THE ARTICLE by P. F. Rogers on Painting Steel Work, in the Nov. issue, page 761, preparing the surface is not covered in detail and I suppose he has in mind the shop coat on new work, which is usually in good condition. It sometimes happens that rust spots are present even before fabrication. I have found the best preparation is to use a sand blast as it is not convenient nor expedient to pickle a steel structure of any size.

Red lead paint, made under the specifications of the U. S. Quartermaster's Dept. or the State of Iowa, is not expensive, the requirements being a pure linseed oil mixture of red lead and some inert extender, both specifications being framed to exclude barytes, whiting or gypsum. The State of Iowa prescribes 50 per cent red lead, the U. S. a somewhat higher proportion.

Iron oxide paints, other than venetian red, are good if made with linseed oil exclusively, although venetian red contains calcium sulphate (gypsum) which is slightly rust stimulative. The State of Illinois specifies blue lead exclusively for first and third coats on bridges and highways, but if the first coat be applied properly, and of good material, subsequent coats can be anything desired, even a poor paint will chalk down to the priming and then stop. As it costs about $3 to $4 for labor to apply $1 worth of paint, it does not pay to buy cheap paint.

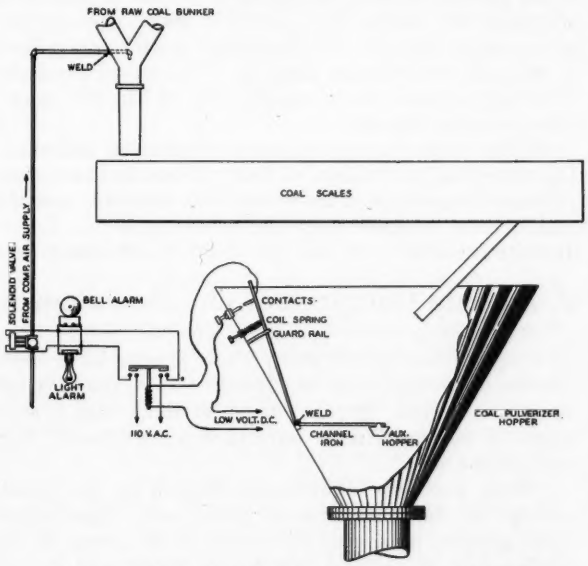
In painting galvanized iron, use only six ounces of copper acetate to a gallon of water and there will be no excess to wash off. A velvety black coat of copper oxide will be formed on the surface of the zinc coating which will prevent cracking and peeling if good paint is used.

St. Louis, Mo. L. R. BAKER.

Eliminating Damp Coal Difficulties

An industrial plant operating five boilers with the unit system of pulverized coal has had considerable difficulty in operation due to damp coal. The most trouble was had at seasons of the year when the coal became wet in transportation from heavy rains or snows. It then had the tendency to cake or pack together and stick in the raw coal system. In the base of the steel bunkers and the lateral of the coal pipes to the scales this trouble occurred frequently.

Some type of alarm combined with a method to free the coal system was desired and the drawing shows the construction of such a device. A small sheet steel hopper was made, open at the top and bottom and about 10 in. square at the top. This hopper was suspended by a piece of cold rolled steel stock about ½ in. diameter by 12 in. long. This in turn hung on the end of the lever arm.



DEVICE TO GIVE WARNING OF COAL FAILURE

The lever arm was made up of two pieces of rectangular steel or strap iron about ¼ by 2 in. and they were welded together "flat to flat" at their ends to form an inside angle of slightly over 90 deg. A 9/16-in. hole was drilled through this welded junction and another piece of ½-in. round stock served as the pivot. The pivot rod was mounted in two holes drilled in a piece of channel iron which was bolted to the inside of the pulverizer hopper. The pieces of round stock were prevented from working out of their mounting by collars and set screws at each end.

At the top of the pulverizer hopper a copper contact point was placed, mounted in a fiber bushing. A similar contact was fastened at the end of the lever arm at the correct height to make connection with the stationary contact. ¼-in. copper bolts served for the contacts in this case. When the lever arm is in correct position the lower leg will be horizontal and the top of the vertical arm is about 12 in. away from the side of the main hopper. A piece of strap iron was bent and bolted onto the side of the hopper to act as a stop rail for the vertical arm and prevent its moving any further out from the side of the hopper than just far enough to allow the lower leg to swing down to the horizontal. A coil spring was fastened, one end to the vertical lever arm near the contact points and the other end to an adjusting bolt. This bolt is put through a hole drilled in the side of the main hopper from the outside and has a locknut to hold it in the position to give the correct spring tension.

A ½-in. pipe was run through a hole drilled in the side of the coal pipe lateral with its end bent at right angles and pointing down. This line was welded in position. A solenoid valve connected in this ½-in. line had its coil arranged so as to open the valve when energized. The half-inch line was then connected up to the compressed air supply which operated at 100 to 150-lb. pressure. A bell and light were mounted on the boiler room wall near the solenoid valve.

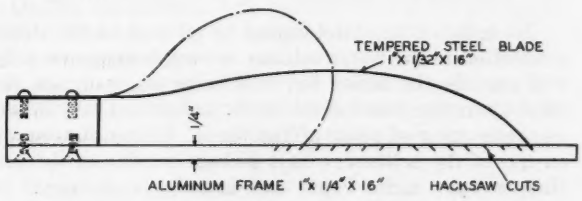
The copper contacts were then connected in one line of a low voltage supply going to a relay. The relay contactors operated the bell and light alarm and the solenoid valve.

In former operation the first warning the operators would have of the coal supply failing due to pipes plugging up or any other cause would be when the steam pressure started to drop after the fires went out unless they happened to be right at the coal spout at the right time. By the time the flow of coal was again established and the burners lit a serious drop in pressure occurred together with a dangerous fluctuation in the boiler water level. With the arrangement shown, as soon as the coal supply fails for any reason and the coal level in the pulverizer hopper falls below the level of the auxiliary hopper, the tension of the coil spring overcomes the weight of the small emptied hopper and causes the lever arm to swing back closing the contact points. This in turn causes the relay to operate the bell and light alarm and open the solenoid valve. If the coal supply has failed due to sticking in the pipes the jet of air usually frees it. In any case the alarm calls the operator's attention and gives him a time interval of several minutes to correct the difficulty before losing the fires.

Milford, N. J. HARRY M. SPRING.

Simple Instrument Aids Drawing of Irregular Curves

As every draftsman knows, the template type of irregular curves will form only a series of rather short arcs of a long, flat curve. The device sketched herewith will be found useful in drawing many of the long type of curves frequently encountered in engineering work, such as motor and generator characteristics.



INSTRUMENT FOR DRAWING IRREGULAR CURVES

The materials necessary to make this instrument are such as can be found around most any shop or work bench. Any desired length may be chosen, but the 16-in. blade has been found very convenient.

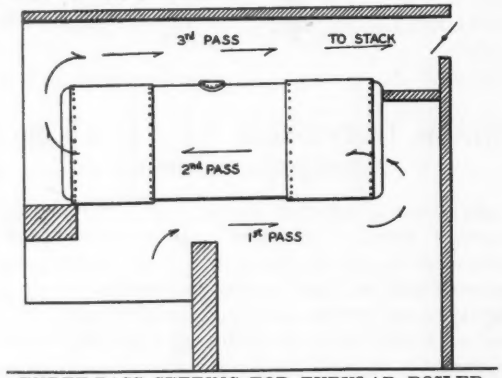
A. & M. College, Miss. O. D. GOAD.

External Corrosion of 3-Pass Tubular Boiler

EXTERNAL CORROSION is principally caused by leakage moisture that is in contact with soot, ashes and the hot gases of combustion on the shell of a boiler, forming sulphuric acid which destroys the metal in a short time. It is not a common occurrence but it should receive careful attention, as it usually progresses to a serious extent before being discovered.

Tops of these boilers are hard to clean and shell plates quite often are not accessible for proper inspection. The sides of the boiler are bricked up and cannot be examined. Small leaks on the top of a boiler below the top brick work do not show and are easy to neglect. When the manhole is in the top shell it is likely to give trouble by leakage, particularly where the fire is banked over night and the boiler filled with water. If this cannot be kept tight by renewing the gasket, then the seat and plate should be trued up.

In many cases, the steam outlet and safety valve pipes are screwed into a flange that is riveted to the boiler shell. Leakage at these connections is caused by wear, poor threads, poor design and support of piping. It seems like a big job to repair a small leak on this piping but it pays. All seams should, of course, be caulked and kept tight. Many of these boilers are fitted with from two to three soot blowers on the top, made of pipe bent around the top half of the boiler and drilled with small holes to blow the soot to the rear. Blowers are about 4 in. above the top of the shell, the lower ends on each side being plugged. These ends should receive special attention, as water rests here and corrodes through the pipe. The steam then strikes the shell of the boiler and, in a short time, the shell is either cut through or is damaged to such an extent that it is necessary to apply a patch.



THREE-PASS SETTING FOR TUBULAR BOILER

No leaks of any kind should be allowed in the steam connection to the water column as such leakage not only will corrode the boiler but will raise the water in the glass above the water level in the boiler and may result in overheating of some of the parts. If any connection on top of the boiler develops leakage outside of the setting, a light metal chute can usually be arranged to carry this water away from the setting, until such time as the leak can be repaired.

Tops of all 3-pass boilers should be examined at least twice a week while in service for leakage. When they are out of service for repairs the tops should be cleaned as well as the other parts and should then be examined closely for leakage and evidence of uniform corrosion. This form of corrosion is hard to discover by visual inspection, but slight longitudinal depressions near the sides are some indication, as the water is stopped here either by the brick work or by the soot. Look for scale on the shell and examine rivet heads closely for corrosion and evidence of wasting, particularly on the sides at brick work.

Hammer test should then be applied to all accessible parts of the shell and, where there is suspicion or evidence of uniform corrosion, a few test holes for a 3/8 in. pipe tap should be drilled at the points that appear to be thin. If these holes prove the shell to be materially reduced in thickness, the boiler should either be taken out of the setting or sufficient brick work removed to permit a hammer test to be applied to all parts of the shell. Other test holes should then be drilled in that part of the shell that is normally covered by brick work at the sides. When this condition is found to exist the boiler should be held out of service until it has been inspected and passed by a certified boiler inspector as some part of the shell may be wasted to such extent that it will fail under steam pressure. This would result in a serious explosion with probable loss of life and extensive property damage.

While in service a boiler is under continual and varying stress due to changes of temperature and variation of steam pressure, so it should have the best care possible and be kept in good condition at all times.

Harrisburg, Pa. C. M. DIXON.

Ammonia Compressors at Slow Speeds

BE CAREFUL about operating ammonia compressors at a speed that is too slow. Slow speeds have been known to be the cause of expensive ruin, paradoxical as it may sound. We are prone to think that a slow speed of any machine is safer than a high speed. But not always so.

Many ammonia compressors depend on the splash system for the lubrication of piston rods, rings, cylinders, pistons, pins, etc. Naturally, if the speed of the compressor is reduced too much there will be no "splash", hence no lubrication. In one instance recently brought to my attention the compressor speed was reduced from 150 to 100 r.p.m. As a result the pistons, pins and rings became so dry and so worn that they had to be replaced by new ones. They didn't get any oil at all because there was no "splash".

Also, it is a well known fact that designers of ammonia compressors generally base flywheel computations on the normal speed of the compressor. That is, they give the flywheel a weight which is sufficient to run the compressor with a pre-determined speed fluctuation.

Naturally if the compressor is then operated at a low speed, the coefficient of fluctuation will be greater than at normal speed.

This fluctuation sometimes becomes so great as to cause difficulties with belt transmission. I have seen wrapper pulley type drives which fluctuated so violently due to abnormal low speed that the belt would last only one week. The wrapper pulley would be thrown up into the air with each fluctuation and would then come down hard against the belt. No belt can endure such punishment. Troubles of this kind are best remedied by getting back to normal speed.

Newark, N. J. W. F. SCHAPHORST.

Plant Operation Problems

Turbine Water Rates

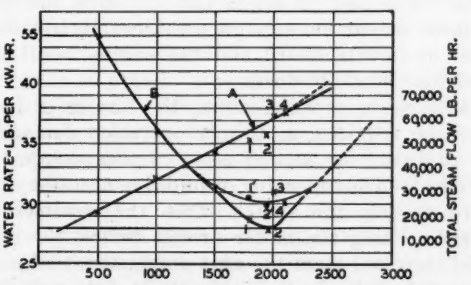
We have a 3000-kw. turbine in our plant which upon test shows a peculiar condition of decreasing water rate to about 2,000 kw. after which the water rate begins to increase as shown by the following data:

TEST DATA OF A 3000-KW. TURBINE

Load in Kw.	Steam Flow Lb. per Hr.	Water Rate Lb. Kw. Hr.
500	22,000	44
1000	36,000	36
1500	47,000	31.3
1800	52,000	28.8
1940	54,000	27.8
2000	62,000	31
2100	63,000	30

During the test the machine was running with extraction valves closed, 28.5 in. vacuum and 175 lb. steam pressure. The valves in this machine are in good condition, the mechanism is free and correctly assembled, and the flowmeter, with which the data were taken, is apparently working as it should. We would like to have your opinion as to this peculiar action. J. S.

A. Turbines are ordinarily designed to have the most efficient point at about three-fourths load. The decreasing water rate to about 2000 kw. in this case indicates that the primary valve is opening and is wide open at the lowest point in the curve. After this the secondary valve opens and as this steam expands through only the last rows of the turbine its efficiency is not as high as the steam through the primary valve and the water rate increases. Furthermore when this additional steam flows through the blades the leaving losses from the lower part of the machine are increased, which further decreases the turbine efficiency.



TEST DATA PLOTTED ON CURVE SHOWS UP ERRORS.

If the data are plotted in the form of a curve as shown errors are more easily detected. After plotting curve A, total steam flow against load it seems probable that points 1 and 2 are too low by about 5000 lb. per hr. The low point in the water rate curve B is probably too low and relocating points 1 and 2 at 1′ and 2′ the correct curve is probably as shown dotted through points 1′, 2′, 3 and 4. Curve A is ordinarily a straight line up to almost full load at which point it sometimes tips up as shown by the dotted portion.

Boiler Valves and Piping

Will you tell me what valves are needed on the feed water piping, steam lines and blow-off connection of two H.R.T. boilers both connected to the same header?

F. E. B.

A. With no definite information regarding the arrangement and details of the installation and local requirements, it is impossible to answer this question completely. Conditions vary, although what may be considered as the minimum requirements are set forth in the A.S.M.E. Boiler Code. For pressures of over 125 lb. at least extra heavy valves must be used.

In the feed pipe there must be a check valve near the boiler with a valve or cock between the boiler and check so that the latter may be inspected or changed. With two boilers fed from the same source, as in your case, it is necessary to have a globe valve on each branch, the inlet to this globe valve being under the disc. Two methods of feeding, an injector may be one, are necessary for boilers of over 500 sq. ft. Feedwater regulators are installed outside of the check valve and provided with bypass unless there are two complete feed lines to the boiler.

Each steam outlet, except for superheater and safety valve, must have a stop valve near the boiler. This must be of 2 in. or over, outside screw and yoke rising spindle type. With two boilers on a main, two stop valves must be used with a free blow drain between them and the discharge end of this drain visible to the operator of the valve. If possible, the stop valve next to the boiler should be an automatic, non-return type and the other an O.S.&Y. type, although two O.S.&Y. valves are allowed by the Code.

Minimum size of blow-off valves is 1 in., the maximum 2½ in. No globe valves are to be used for this service and for pressures of over 125 lb. two valves must be used in tandem. These two valves may be in separate or in a single valve body. All blow-off piping must be for full working pressure and installed so it can be inspected over the full length.

Many, if not all, cities have restrictions regarding emptying of hot water into sewers and in this case the blowoff must be cooled, either by radiation or by shooting with cold water before discharging to the sewer.

On the main steam line a drain should be provided at all points where moisture or condensate may collect. Traps should be bypassed and so piped and valved that they can be removed for repair without making the drain line on which they are installed unoperative. This means a minimum of 3 valves for each trap, one on each side of the trap and one in the bypass.

Cause of Reverse Hot Water Flow

IN ANSWER to the hot water heating problem on page 783 of the November issue of Power Plant Engineering, I would state as my belief that the reversal of flow was due to the siphoning action which is the principle employed in the steam loop used to return water

of condensation from a steam pipe, steam heating system or steam separator to the boiler without traps or pumps. The accompanying sketch and following description from a text book of the International Correspondence Schools shows how the steam loop operates.

The loop consists essentially of a riser, D, a bend, I, acting as a check, a so-called horizontal E, a drop leg, F, and a check valve and globe valve in the pipe connecting the bottom of the drop leg to the boiler. While the steam loop can be operated without a check valve in the delivery pipe of the boiler, it should not be done on account of the danger of the water in boiler, A, blowing back through the loop in case the pressure, in pipes

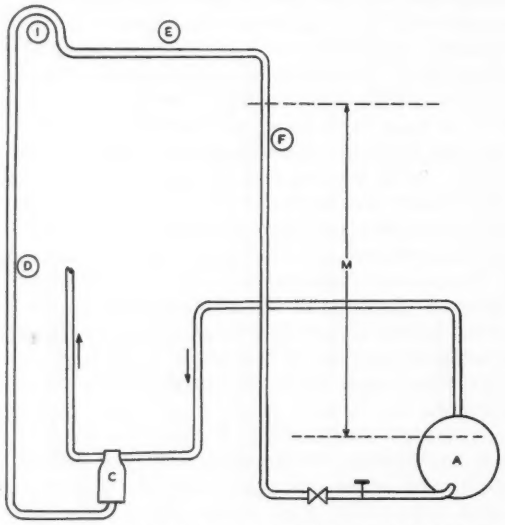


DIAGRAM OF CONDENSATE RETURN LOOP

or other apparatus being drained, drops abnormally below that in the boiler.

With check valve in delivery pipe, the operation is as follows: On account of the comparative altitude of I and E and the condensation of the steam the pressure in the horizontal E will be a little less than in the separator (C in sketch), coils or other condensation producing apparatus. Therefore the steam flows in riser D and through bend, I, into horizontal, E, where it is condensed, and flows on into drop leg.

Any water in C or other source will be carried along with the steam, bend I prevents its return down the riser, this water flows through E into drop leg, F, raising the water level to a height in the drop leg, F, until the pressure due to its head, added to the pressure in E is great enough to overcome the pressure in the boiler when the check valve, X, is forced open and the water flows into the boiler until the water drops to a point in F where the pressure in F due to the head of water and steam pressure combined is less than the boiler pressure, when the check closes. The head of water in F is measured between the water level in the boiler and the level at which the water stands in F. The distance, M, in feet depends on the difference in pressure existing at the separator or point similar in location and the boiler pressure. Ordinarily about 2.5 ft. should be allowed for each pound difference in pressure.

To my mind this very nearly approximates the action of the water heating problem presented.

Superior, Wis. FRED S. RUTLEDGE.

Synchronizing with the Power Co.

IN REGARD TO the problem of C. P., on page 831 of the Dec. issue, I believe that he can successfully synchronize his alternator with the power company's lines.

Very often, when the usual motor driven device would be out of order, either on engines or hydroelectric units, or, when for various reasons the hydrogovernor would be on the "hand control" feature, I have found it not only possible, but necessary, to synchronize without the rather convenient motor driven device.

It is often necessary, when synchronizing by use of the throttle, that two men must be used, a man at the switchboard, and a man at the throttle valve, the latter to bring the unit up to speed, and keep it regulated until properly synchronized.

It would be very convenient to have the synchroscope installed so that it would be in full view, not only of the operator, but of the engine attendant as well. This feature would enable the attendant to keep the unit at the right speed without any attention from the operator, and would allow the latter to give his undivided attention to the switchboard. If the above is not practical, I would advise the installation of a reliable tachometer near the engine.

Due to the comparatively extreme speed fluctuation when using the throttle valve in this manner, the use of a voltage regulator would also be advisable. Although an instrument would likely cost as much as a motor driven synchronizing device, its benefits would be manifold, as not only would it allow the operator to do a much neater job of synchronizing, but would be a great help to the entire plant as well.

Once the alternator is on the line its load can easily be regulated by the manipulation of the throttle valve. Here again the voltage regulator would be useful, as it would keep the voltage steady as the load changed.

However, it is the opinion of the writer that the installation of the motor driven device would be a good investment. It is very likely that the switchboard is invisible from a position near the throttle, and the change of load would necessitate the attention of two men, and its attendant confusion. Or else the engineer would have to do considerable traveling between the switchboard and the engine, until the desired load was obtained.

Also, when shutting down, the service of two men would be required, as proper operation demands that the alternator be neither motored, nor dumped off at full load. The operator would be necessary at the board to trip the switch when the wattmeter read "zero". Using the motor driven device, the operator could stop and start the unit unassisted, and make all the required load changes without help, which is of a great benefit in these days of shorthanded engine rooms.

Therefore, while it is entirely possible to operate this unit from the throttle, the use of the motor driven device would be much more satisfactory, and no doubt would pay for itself in a short time.

Central Islip, L. I., N. Y. WILLIAM SHEFFER.

IF ALL the atomic energy in one pound of matter—ice, coal, iron or anything else—could be utilized it would deliver 10,000 hp. for 90 yr.

Wide Variety of Subjects Discussed at A.I.E.E. Winter Meeting

NOTWITHSTANDING adverse business conditions, the winter convention of the American Institute of Electrical Engineers held in New York, January 23rd to 27th was well attended and the technical meetings exhibited an unusual interest in many new problems which the continual advance in the art presents. The attendance which was approximately 1100 was not so large as in previous years but under present conditions this was an unusually good showing.

Altogether there were thirteen sessions, each devoted to specialized problems but they were paralleled so that those which held interests in common did not conflict seriously with one another. In the electrical art as in other fields, development has reached such a degree of specialization that it is extremely difficult for an individual to know what is transpiring in the field as a whole. It is in this that these technical meetings are most valuable for it gives those who attend an opportunity to learn what is being done in the other branches of the art.

A particular example may be cited in the session on Electrochemistry and Electrometallurgy which was an important feature of this meeting. The perfectly amazing accomplishments in the field of electrochemistry in recent years are only vaguely understood by the electrical engineers concerned primarily with generation, transmission or distribution problems or to those in the communication field. And so, Colin G. Fink's lecture on "Increasing Applications of Electricity to Chemical Processes" was one of the most interesting of the entire convention. At this session among other things, Professor Fink stressed the importance of aluminum and pointed out that the trend to its use is so rapid that the amount of electric power used in its manufacture will double in nine years. He pointed out that whereas in the past we have come up through the stone age, bronze age to what at present we may call the steel age, the next age to come will undoubtedly be the aluminum age.

In order to present a more complete picture of the convention, we will outline briefly the important features of each session in the order in which they were held. The most important of the papers presented at these sessions will be abstracted in subsequent issues of Power Plant Engineering.

The meeting was opened officially at 2:00 p. m. Monday, January 23, with an address by H. P. Charlesworth, president of the Institute, and by the formal presentation of the Alfred Noble prize, to Frank M. Starr for his technical paper "Equivalent Circuits—I." This presentation was followed immediately by the first technical session, devoted to the general subject of Automatic Stations. Perhaps the most interesting paper at this session was the one by F. H. Gulliksen of the Central Engineering Dept. of the Westinghouse Co., on "The Principle of the Condenser Discharge Applied to Central Station Control Problems." This is another of the many new applications of electronic tubes, to power problems and is based upon the fact that the combination of a condenser discharge circuit and an electronic tube provides the fundamental elements for indicating the rate of change and the direction of change of an electric potential. Mr. Gulliksen outlined the fundamental principle of the condenser discharge circuit and described its application in connection with three specific electronic control devices, namely, an impulse relay, an electronic voltage regulator and an automatic synchronizer. The latter is especially interesting since it requires only 5 voltamperes per potential transformer.

Simultaneously, with the sessions on Automatic Stations there was one on Electric Welding which was concerned mainly with questions regarding the fundamental nature of the arc.

Tuesday morning, Jan. 24, was given over to two simultaneous sessions, one on Communication and the other on Rotating Electrical Machinery. The Communication session was devoted entirely to communication systems on railroads. At the Electric Machinery session great interest was displayed in a paper on a "Low Frequency Self-Exciting Commutator Generator" by J. I. Hull of the General Electric Co. In this he described his investigation into the development of a practical, flexible and easily manipulated source of alternating current at frequencies below those advantageous for synchronous alternators, and showed that a machine having these requirements could be produced at moderate cost.

Another paper at this session of considerable interest was one on Synchronous Motor Pulling Into Step Phenomena. This presentation was of particular importance because it showed the application of the Differential Analyzer developed by Dr. Vannevar Bush at the Massachusetts Institute of Technology. This machine it may be recalled has made possible the rapid and accurate solution of the idealized non-linear differential equations of motion of synchronous motors which describe the pulling into step transients. In this paper, Dr. Harold Edgerton together with three other members of the Massachusetts Institute presented these solutions in a useable form.

In the paper, Parallel operation of A. C. Generator, at this same session, M. Stone of the Westinghouse Electric and Mfg. Co. analyzed the action of Governors and Damper Windings on Generating units. This brought out active discussion nearly all of a confirmatory nature, however. Mr. Putnam also of Westinghouse pointed out that in the various governors connected to a number of alternators operating in parallel, a system obtains which is the exact counterpart of the regenerative circuit used in radio receivers and that oscillations in such a system will sustain themselves.

The afternoon sessions on Tuesday were devoted to two subjects, one "Transportation" and the other "Sound Measurement." The latter consisted of a lecture by Dr. Harvey Fletcher of the Bell Telephone

Laboratories in which he explained the development of the modern standard of sound measurement, the decibel.

Wednesday, there were sessions only in the morning, the afternoon being given over to inspection trips. The morning session was devoted largely to a discussion of "Insulation Coordination." Three papers were presented on this subject, one of which constituted a progress report of the transformer subcommittee of the A.I.E.E. machinery committee.

Papers were also presented at this session, on Impulse Voltage Testing. High Current Mercury Arc Rectifiers, and on a Synchronous Mechanical Rectifier Inverter, the latter by Professor Stanley Seyfert of Lehigh University. This paper described a machine which was developed to enable a synchronous commutator of the short circuiting type to perform the two functions of rectification and inversion interchangeably under conditions of comparatively high voltage and high current.

The paper on High Current Mercury Arc Rectifiers by E. H. Reid and C. C. Herskind of the General Electric Co. described a single unit mercury arc rectifier of 3000 kw. rating, at 600 v. This type of unit is in stalled in the new 8th Avenue Subway in New York.

These rectifiers, Mr. Herskind pointed out in the discussion, are more than just rectifiers—they are also Thyratrons and can be used as inverters. They are the first units of this size, and because reliability was a prime consideration in these installations they were designed with ample factors of safety. In the design of rectifiers of this type, the operating temperature will become a more important factor as the sizes increase. These particular units, though the guaranteed continuous rating was three thousand kilowatts, carried momentary overloads of 300 per cent full load current for one minute. These overload tests were limited by the loading facilities available at the factory and do not represent the limit of the rectifier.

On Wednesday night, Bancroft Gherardi was presented with the Edison Medal and after the ceremonies, Dr. J. C. Merriam, president of Carnegie Institute of Washington, delivered a lecture on the "Evolution of Society as Influenced by the Engineer."

Thursday was devoted to four sessions, two in the morning and two in the afternoon. At one of the morning sessions, Colin G. Fink gave the talk on the increasing application of electricity in electro-chemistry and J. V. Alfriend of the Westinghouse laboratories explained how the mixing of compounds can be controlled by electrical machinery rather than by chemists or skilled workers at a fraction of the cost.

Lightning studies begun in previous years have been continued and in the session on "lightning" on Thursday morning, the most recent experience in this field was presented in five papers. At this meeting again, it was brought out that wood pole lines have a distinct advantage in protecting against lightning. A paper by H. L. Melvin of the Electric Bond and Share Co., presented details of the operating experience on a total of some 1300 miles of wood pole line.

A paper on Impulse Voltage Testing by Harding and Sprague, both of Purdue University, was received with considerable interest for, among other things, this paper again showed that with usual city conditions the interconnection of the primary lightning arrester ground and the grounded neutral of the secondary mains on distribution transformer installations, definitely limits transformer stresses to values which should reduce lightning failures to a negligible quantity. This question had been investigated previously by the same authors in which they reached similar conclusions.

In discussing this paper, D. W. Roper of the Commonwealth Edison Co., reported that in Chicago, they had made this interconnection on about 15 per cent of all their distribution transformers. This connection, however, he pointed out is prohibited by the National Electric Safety Code, so consent of the Illinois Commerce Commission was first obtained to make the tests. These connections have remained now, over a considerable period and in all that time no adverse conditions were noted, but investigations disclosed that it effected a reduction of about 40 per cent in transformer failures. This experience indicated the need for changing the National Electric Safety Code in this respect and steps are being taken in that direction.

The remaining sessions on Thursday and Friday were all of absorbing interest, dealing with various problems from instruments and measurements to research and applied electronics. Rectifiers and inverters came in for considerable discussion as did the question of insulation. A paper on higher steam temperatures and pressures by Engle and Moultrop of the Edison Electric Illuminating Co. of Boston provoked considerable discussion regarding various types of new boiler designs and thermodynamic cycles. Dr. Slepian of Westinghouse described a new device called the "ignition," for initiating the cathode of an arc. In this, a pencil of high resistance material carrying a small current into the surface of the mercury pool establishes a local high voltage gradient where the mercury and electrode join. This high gradient ionizes the mercury vapor and ignites the arc at a specific time determined by the place of the ignition voltage.

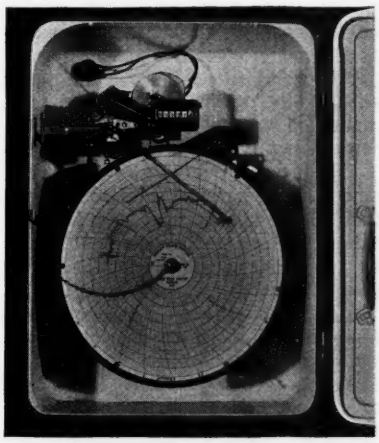
Another feature of importance on Friday was the paper by C. H. Willis of Princeton University on the Application of Harmonic Commutation for Thyratron Inverters and Rectifiers. By the aid of harmonic commutations, inverters can be operated to supply lagging loads and rectifiers can be phase controlled in the leading quadrant. A rectifier which is phase controlled 90 degrees leading becomes equivalent to a synchronous condenser and thus may be used for power factor correction. Professor Willis described a duplex type of circuit which enables a polyphase inverter to produce a sinusoidal voltage and current and permits a rectifier to draw a sinusoidal current from the a.c. system.

Dr. Whitehead, of Johns Hopkins, added to his many contributions to the Institute records in the field of insulation research by another paper dealing with the dielectric losses in impregnated paper. This paper reported measurements of the electrical and physical properties of 10 insulating oils, of a single grade of wood pulp paper and of the paper when impregnated with each of the oils. Of the total increase of the loss found in impregnated paper, over the separate losses in oil and in dry paper, one component is proportional to the effective conductivity of the oil The other component, due to reversible absorption, is, for a given paper, a definite function of the free ion content of the oil as indicated by the product of the conductivity by the viscosity. These relations hold over the entire ranges of type of oil and temperature under study.

New Equipment

Escapement Type Integrator

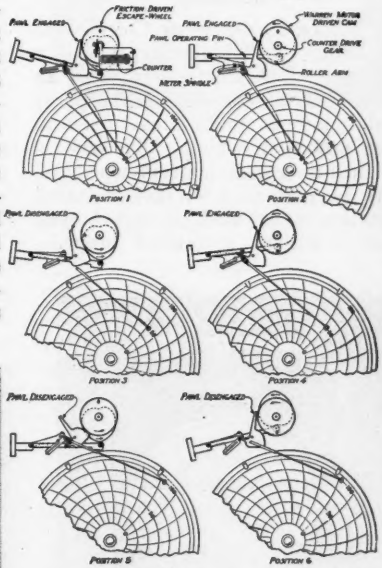
BAILEY FLUID meters recently announced, incorporate the escapement type integrator, which operates in an exceedingly simple but accurate manner, giving the total flow in gallons, pounds or other units on a six-figure counter. The principle of operation is diagrammatically represented by the cut herewith. A heart-shaped cam, which has a uniform angular rise, is geared to a Warren Synchronous Motor and rotated at the rate of two revolutions per minute. By means of a friction clutch between the cam and the escape wheel, the motor also drives the escape wheel and integrator counter at constant speed when the pawl is not engaged. When the pawl engages with the escape wheel, the integrator counter is held stationary, but the friction clutch allows the cam to continue rotation.



As the roller arm is pivoted near its left end to the flow mechanism, the position of the pivot varies only with changes in the rate of flow. The right end of the roller arm moves up and down under the action of the rotating cam, causing the pawl operating pin to move up and down also. It is this operating pin which is responsible for engagement and disengagement of the pawl with the escape wheel.

Referring to the illustration, Positions 1 and 2 show the flow recorder at zero rate of flow. In Position 1, the cam and roller are at maximum throw, while in Position 2 they are at the point of minimum throw. In both of these zero rate of flow positions, which represent extreme cam positions, the integrator counter is stationary because the path of the pawl operating pin does not come sufficiently low to disengage the pawl.

Positions 3 and 4 also show the cam and roller in their extreme positions, but the flow recorder is now at 50 per cent of maximum



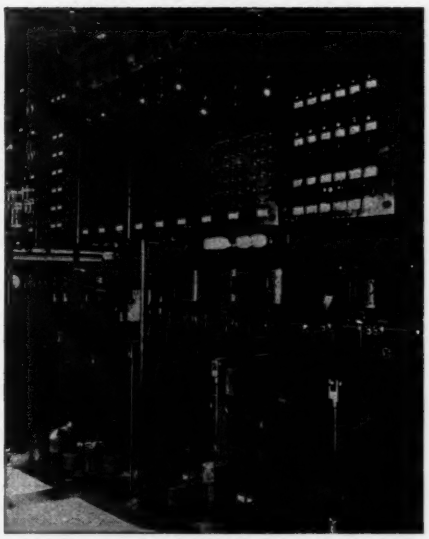
capacity. The increase in rate of flow has resulted in lowering the left end of the roller arm, thus lowering the path traveled by the operating pin. Consequently, during 180 deg. rotation of the cam, the pawl remains engaged with the escape wheel. Under these conditions, the integrator runs 50 per cent of the time.

Positions 5 and 6 show the cam and roller in similar positions, but with the rate of flow increased to 100 per cent. Under these conditions the integrator runs continuously.

Where Millionths of an Inch Count

WHEN HOT, METALS slowly yield under a steady pull, like taffy or cold tar, so P. G. McVetty of the Westinghouse Research Laboratory, patiently investigates this "creep" at high temperature by means of a long row of scientific apparatus. Automatically held at exact temperatures in individual furnaces, various samples carry heavy loads for months, while sensitive instruments indicate changes of a millionth of an inch. Curves are plotted and the alloys best suited for turbine blades are then selected.

Today the low-pressure blade types of steam turbines attain peripheral speeds of almost 15 mi. a min. and the high-pressure blades



operate in temperatures of over 800° F. The testing for creep of steam turbine materials represents the highest order of sensitivity and accuracy in all details of the testing procedure. To measure creep rates of this order of magnitude requires not only the measurement of extremely small length changes but, precise measurement and control of temperatures.

While the creep test is the best known means of predicting the value of a material for high temperature service involving small permissible deformations, its limitations must not be ignored. At best, the length of a creep test is small compared to the time during which a material is expected to give satisfactory service. Extrapolation of creep curves is necessary but great care is essential if large errors are to be avoided.

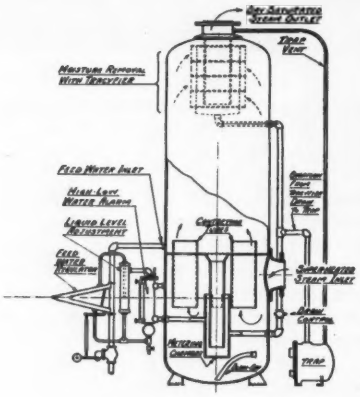
It is generally agreed that creep is affected by the previous history of the material especially in the case of alloys which exhibit age-hardening tendencies. We may have, for

example, a creep test in which the measured creep rate is negative because some structural change completely hides the creep. A more dangerous case is the one in which the creep is reduced to a small value during the test by age hardening. In this case the danger lies in the probability of an increased creep rate after the maximum age hardening effect is passed in service.

Neither the designer nor the testing engineer can extrapolate the creep curves with accuracy if internal changes in the metal are proceeding during the test and in subsequent service. This gives to the metallurgist a real problem in producing alloys which are not only resistant to creep but also structurally stable under service conditions of stress and temperature during the service life of the material.

Blaw-Knox Desuperheater

BLAW-KNOX CO. of Pittsburgh, Pennsylvania, has added to its line of steam power equipment a desuperheater which embraces in one piece of apparatus, complete desuperheating with steam purification. Essentially the Blaw-Knox desuperheater consists of a Blaw-Knox contactor combined with a Tracyfier and equipped with a standard make of boiler feedwater regulator.



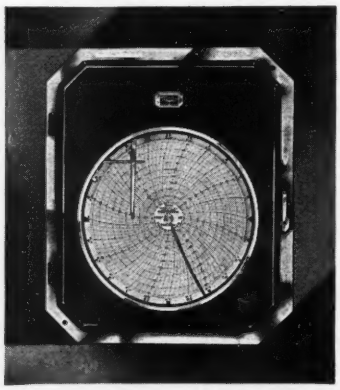
By the action within the desuperheater, a large supply of water is automatically forced into extremely intimate contact with the steam, insuring complete elimination of superheat. Due to this same action and the fact that a large surplus of water is present in contact with the steam, changes in quantity of steam passed, increases or decreases in the amount of superheat, or changes in steam pressure are immediately and automatically cared for.

No auxiliary equipment is required for circulating surplus water, and no surplus feed is required by this desuperheater other than that necessitated for blowing down the water reservoir to maintain the soluble and insoluble salt content within reasonable limits.

Any solids carried in the superheated steam are retained by the water and gradually concentrated, eventually being removed by the required amount of blowdowns. Any solids contained in the water mist above the contacting tubes are prevented from leaving the desuperheater by the Tracyfier.

Recording Instruments

TAYLOR INSTRUMENT COMPANIES, Rochester, N. Y., announces a new recorder. This instrument has an aluminum die cast case, is rustproof and combines mechanical strength with minimum weight. The case is finished in smooth lustrous black and may be had as a surface mounted instrument or flush mounted type with or without a polished flange.



The new Taylor recorders are standard on mercury instruments but gas or vapor actuated systems are also available. The instruments are available as one, two or three pen recorders for either temperature or pressure, or any combination. An electric clock can be supplied instead of the standard spring wound clock, if desired.

An important feature of the mercury actuated instrument is Taylor Accuratus Tubing. This tubing automatically compensates for any temperature changes along its path without the use of any auxiliary devices or extra tube systems. Employing accurate small bore steel tubing, this capillary insures great accuracy where surrounding temperature changes are apt to affect the thermometer readings. Lengths up to 100 ft. or more may be used. With Taylor Accuratus Tubing, only true bulb temperatures are recorded.

Smoke Tube Draft Gage

USE OF SMOKE in a calibrated glass tube to indicate the draft in boiler settings is an idea recently developed by E. Vernon Hill Co. of Chicago. In this portable smoke tube draft gage there is an actual flow of air through the instrument, i.e., down through the orifice then reversing and passing out to the connection. The flow through the fixed orifice is determined by the difference in pressure between that in the furnace or breeching and the atmosphere surrounding the gage.

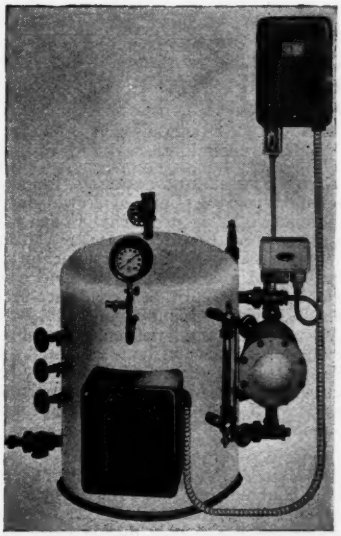
This flow of air downward through the intake nozzle forms a jet in the tube which clears the

smoke from the upper portion as far as the jet is effective which is proportional to the difference in pressure. The tube is calibrated in inches of water by actual tests and comparison with a master gage.

To fill the tube with smoke, remove the plug from the bottom and blow dense smoke from a cigar or cigarette through the tube. Replace the plug, close intake nozzle with thumb, insert static tip wherever a reading is to be taken, remove thumb from intake, then read position of smoke meniscus on the scale which gives the static pressure in inches of water.

Steam by Wire

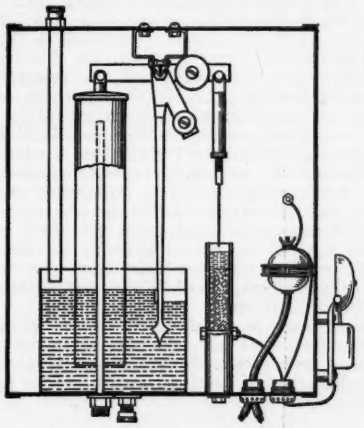
TO FURNISH steam in small quantities, equivalent to 1/5 to 8¾ boiler horsepower, at any pressure up to 200 lb., Commonwealth Electric and Mfg. Co., Boston, is offering a line of electric-heated, automatic steam boilers. They are for 110 or 220 v. systems, taking from 2 to 90 kw. according to steam capacity, using General Electric Co. immersion and switching units. Operation is by throwing a switch as pressure is regulated by an automatic controller; heat will be shut off if water level falls too low. Where supply water pressure is 15

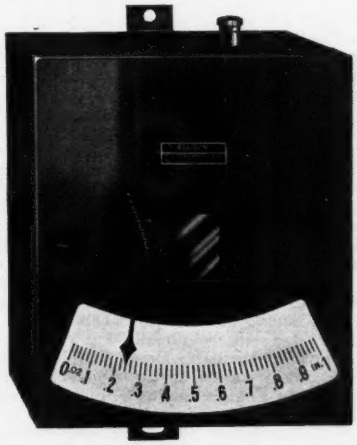


lb. above maximum steam pressure, water level can be regulated by automatic float, in other cases by automatic control of a motor-driven feed pump, which will handle return condensate and make up water.

Draft Gage Alarm

FOR ELLISON pointer draft gages a sensitive and durable electric alarm system has been developed by the Ellison Draft Gage Co., 214 W. Kinzie Street, Chicago. It can be furnished in either the Ellison straight-line or the dial type pointer draft gages for minus, plus or differential readings and for either high or low draft alarm. Transformer can be furnished for either 220 or 110 v., dry cells being used for other than a.c. current. The system consists of a transformer, a bell, and a mercury chamber and contact rod comprising the switch. The chamber is composed of hard fibre which is partly filled with mercury, which is covered with oil for sealing the electric arc and also for sealing the mercury against oxidation. The electric contact rod is suspended on the beam of the gage, on a knife edge bearing and is adjustable so as to ring the bell at any point of the scale, within a variation not to exceed 0.01 in.





The line cut shows the dial type gage equipped with alarm for low minus draft. The halftone cut shows the gage with 1-in. scale range.

PERMITE RESALUM is being introduced by Aluminum Industries, Inc., of Cincinnati, in two forms, heat resisting and non-corrosive, for surfaces where a protective coating of aluminum paint is desired. It can be used by spraying, brushing or dipping and is claimed to cover with much thinner coating than ordinary paint.

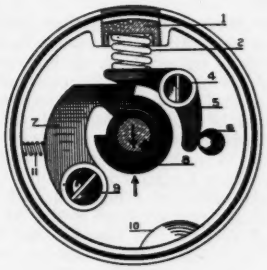
KELPO FREE-WHEELING clutch for capacities up to 500 hp. is introduced by Kelpo Clutch Co., Rockford, Ill., for driving pumps, fans, generators and the like. It is used like a flexible coupling and permits the driven member to run free at faster speed than the driver without drag on the driver when that is slowed down for any reason.

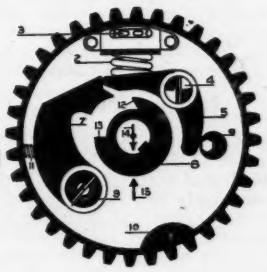
SWITCH & PANEL DIVISION of the Square D Co., Detroit, Michigan, has introduced a line of fuse panelettes for switched circuits, in which the front trim may be removed by taking out four corner screws. The flush trim is finished in black crystallac and oblong knockouts are provided for the switches, one knockout each circuit, thus permitting the mounting of only the required number but allowing for future circuits.

LINK BELT CO. announces a new underfeed screw stoker in capacities of 10 to 250 b.h.p. with variable speed transmission and automatic control from boiler pressure.

Overload Releasing Clutch

WHEN THE load on a machine driven through the G-O-B automatic mechanical overload releasing check exceeds that for which it is adjusted, the driving pawl, 7, held by the load spring, 2, in contact with the angular contact point on the bushing, keyed to the shaft, is instantly released and thrown into a locked position as shown in the second cut. This is accomplished by giving the





proper angle to contact point, 12, and by adjusting the spring, 2, to the proper tension. To reset the driving pawl in its engaged position, the body to which the driving pawl is fixed is turned until the arrow points, 14 and 15, face each other. The cam, 6, is then turned which allows the pawl to drop into its driving position.

This new product of the G-O-B Engineering Co. of Chicago, Ill., is applicable to flywheels, belt wheels, gears or couplings driving such machinery as presses, stokers, crushers or other machinery liable to damage from unforeseen overloads.

POTENTIOMETER STABILOG, the latest addition to the control equipment manufactured by the Foxboro Co., gives automatic control for temperatures up to 2800 deg. F. It can be used where there is great distance or difference in height between the controller and point of measurement. It is non-recording but a record of operation can be made from the same thermocouple on a recording pyrometer, as many as six couples being connected to one multiple point recorder.

News From the Field

RILEY STOKER CORPN., Worcester, Mass., announces that sales of its steam generating and fuel burning equipment will be handled by Messrs. Hardin, Oswald and Moyer, C. L. Smith continuing his association with the office at 1101 Marquette Bldg., Chicago. An Indianapolis office has been opened at 420 Continental Bank Bldg. for that territory, in charge of B. J. Schneider.

J. P. GREENWOOD of Dallas, for many years a consulting engineer in Louisiana and Texas, passed away at his home on Jan. 13, from a cerebral hemmorhage. He built several of the largest southern oil mills and in 1928 designed two plants for the Russian Government. He was a contributor to technical journals, including Power Plant Engineering and in 1931 collaborated with Dr. Hans Heller of Berlin in writing a text book on industrial chemistry of cotton. His son, Gordon Greenwood will continue the consulting practice.

EDWARD P. CONNELL, who has been with the Falk Corporation of Milwaukee since 1913 has been appointed a vice-president, retaining his position as comptroller.

F. J. KING, chief engineer of The Linde Air Products Co., was elected President of the Compressed Gas Manufacturers' Association at the annual meeting held at the Waldorf-Astoria in New York. He has been closely identified with the manufacture of oxygen and acetylene and the development of their applications, particularly in the expanding use of the oxy-acetylene welding and cutting process.

KIELEY & MUELLER, Inc., announces the appointment of United Equipment Corp., 245 South Third St., Columbus, Ohio, as its representative in the state of Ohio except the Cleveland district, also for eastern Kentucky and the western part of West Virginia. Also the appointment of E. H. Bollenbacher, Atlanta, Ga., as representative in the states of Georgia, Florida, Alabama and eastern Tennessee.

FOOTE BROTHERS Gear and Machine Co. announces the appointment of William E. Peck, to succeed Ralph Wirth, in the state of Indiana, with the exception of the counties of Lake, Porter and La Porte, and the Ohio River towns.

GREENE, TWEED & Co. of New York has announced the election of the following officers: Henry S. Demarest, president; James A. McKeon, vice-president and Herbert A. Erwood, secretary. Resignations were tendered by Willard R. Platt, former president, and Harold B. Platt, vice-president.

OFFICERS of the Central Power and Light Co., Corpus Christi, Texas, for the current year have just been announced by the company. At a recent meeting of the company's Board of Directors the following officers were elected: James C. Kennedy, president; E. B. Neiswanger, vice-president; H. C. Loehr, vice-president; F. E. Kruesi, vice-president; W. D. Boone, secretary-treasurer. James C. Kennedy was formerly president of the Central and South West Utilities Co., Dallas, Texas, and was chairman of the Central Power and Light Co.

PLANS FOR THE conference of engineers during Engineering Week, June 25-30, of the Century of Progress Exposition are making excellent progress.

Preliminary plans for the national meeting of the American Society of Mechanical Engineers at the Palmer House call for sessions on fuels and various phases of central station and industrial power plant practice. In addition to these meetings some twenty of the national engineering societies will participate with sectional and national meetings.

During the week prior to Engineering Week the American Association for the Advancement of Science meets in Chicago. Many internationally known scientists will participate, Dr. R. A. Millikan arranging a session on the Application of Physics to Engineering as a joint meeting of a number of engineering groups to begin the activities of Engineering Week, Sunday evening, June 25.

Most of the exhibits at the Century of Progress Exposition will be of a broad educational character but at the Midwestern Engineering and Power Exposition in the Coliseum engineering developments will be interpreted in terms of individual manufacturers' products, as some 300 companies will show their latest equipment for the efficient production and utilization of power.

UNITED ENGINEERING SOCIETIES, Inc., has elected Harold V. Coes of Ford, Bacon & Davis, N. Y. as president; Charles A. Mead of the Board of Public Utility Commissions of N. J. as first vice-president; R. M. Roosevelt of Eagle-Picher Lead Co., New York as second vice-president. Clifford P. Hunt of Chemical Bank & Trust Co. was reëlected treasurer, Arthur S. Tuttle assistant treasurer and Alfred D. Flinn, secretary. Mr. Coes, Mr. Tuttle and John V. N. Dorr were elected members of the board of Engineering Foundation.

EDWARD ALLINGER, who was connected with Hammersley Manufacturing Co., Garfield, N. J., for past 15 yr. as chief engineer, died suddenly during early part of January. George Moreland, formerly assistant chief engineer, has been appointed in Mr. Allinger's place.

E. A. LIVINGSTONE has been appointed a sales representative of The Babcock & Wilcox Co. and The Babcock & Wilcox Tube Co., with headquarters at 85 Liberty Street, New York City. He is engaged in the sale of the seamless steel and alloy tubular products and special process equipment including alloy castings and fusion-welded pressure vessels.

For the Engineer's Library

POWER AND THE PUBLIC. Published by the American Academy of Political and Social Science, 3457 Walnut Street, Philadelphia, Pa. Paper cover, 6 by 9 in.; 155 pages. Price to non-members, $2.

This volume contains the papers presented at a special conference of the Academy held in Philadelphia. The conference was planned because of the conviction of the officers of the Academy that a number of the problems presented by the relations between the public utilities and the general public are among the most urgent now facing us for solution. Careful reading of the papers will show that sharply divergent points of view are presented. This was, of course, deliberately planned, since the Academy undertakes to present different points of view as fully as possible in connection with all important public questions. Representatives of the public utilities and their sharp critics were glad to join in the discussion from the same platform in the hope that through frank exchanges of views and a comparison of factual data, light would be shed on their mutual problems.

Field and Function of the Holding Company was discussed in three papers.

Rates—Domestic, Commercial and Power was the general subject of four papers.

The general subject of Valuation was treated also Public or Private Ownership.

The speeches are indexed and in the back of the book is a book department containing reviews of many interesting books on economic and social questions.

WELDING WITH MANUFACTURED, NATURAL AND MIXED GAS is the title of a 112 page paper-bound report published by the Engineering Experiment Station, Purdue University, Lafayette, Ind., as research series No. 41, price 50c. The purpose of the investigation was to determine the limits of welding with 550, 800 and 1000 B.t.u. gas. Tests made revealed that standard commercial torches were unsatisfactory for handling oxy-gas mixtures and 4 torches were developed in the laboratory. Although sound welds have been made in steel up to ¼ in. in thickness, the heat potential of the gases limits them economically to a thickness of ⅛ in. or less. Strong ductile butt welds in 18 gage sheet have been made by hand at the rate of 90 ft. an hour. Cast iron up to 1¼ in. in thickness and metals having melting points below that of steel are easily welded by the methods described.

IN BULLETIN 243, published by the Engineering Experiment Station, University of Illinois, Urbana, Ill., are reported the results of an investigation on the creep of lead and lead alloys used for cable sheathing. One of the conclusions reached was that the tests showed that, with the exception of one calcium alloy and one antimony alloy, a stress of 200 lb. per sq. in. is apparently a fair average value to assign as a practical creep limit for the alloys studied over the temperature range of 32 to 150 deg. F. The report is a 26-page paper bound pamphlet, which sells for 15c although a few copies are available for free distribution.

USES OF Enduro stainless steel for architectural and building purposes with information as to properties, fabrication, shapes and finishes available are given in bulletin 217-B issued by Republic Steel Corpn., Youngstown, Ohio.

HENRY VOGT MACHINE CO. of Louisville, Ky., has just issued a pamphlet illustrating applications of Vogt fusion welding and presenting tables of tests conducted on welded products. The company also issued cards giving a summary of welded vessel requirements for unfired pressure vessels.

ROBINS CONVEYING BELT CO., New York, has just issued its bulletin No. 82, entitled "Robins Belt Conveyors" which contains tables and charts for determining the capacity, speed, width, power and belt ply for any belt conveyor and considerable other tabulated data in an unusually convenient form.

ATLAS VALVE CO., 282 South St., Newark, N. J., is announcing the Victor Temperature Regulator Data and Price Book pertaining to Victor Self-Contained Vapor Types of temperature regulators for liquids. Four types are featured. In addition to describing fully the temperature regulators, illustrations of actual applications to fuel oil control, desuperheating and controlling the temperature of liquids under various conditions are shown, with one page describing and illustrating other Atlas regulating devices.

BETTER HEATING from low cost coal, with Wing system of combustion control is discussed in bulletin No. M-56 of the L. J. Wing Mfg. Co., 154 W. 14th St., New York City. Examples of savings in building plants are given, burning small anthracite by this system.

IN BULLETIN No. 5000, Northern Pump Co., Minneapolis, Minn., describes its rotary, radial piston pumps in detail, gives sizes, capacities and dimensions for 1 to 200 g.p.m. up to 4000 lb. pressure. Discharge may be regulated from zero to maximum capacity and may be reversed without stopping the pump or changing speed.

COMBATING CORROSION OF PIPING is discussed in a paper by C. E. Joos and V. A. Rohlin, engineers of the Cochrane Corp., Philadelphia, by which concern reprints are being distributed. The paper takes up causes of corrosion, including acidity, oxygen in solution and electrolysis, particularly the significant factor known as "hydrogenion concentration." Whether the solution of iron will continue indefinitely depends upon whether or not the ferrous hydrate formed is removed by the agency of oxygen in solution. Methods of eliminating oxygen from solution are explained, also various arrangements for deaerators to make possible the use of iron or steel piping in hot water service systems without trouble from rusting.

SCHUTTE & KOERTING CO., Philadelphia, has just issued its bulletin No. 6-F describing S-K Rotameters and flow indicators for liquids and gases.

SPECIFICATIONS for grey cast iron in sections ¼ to 4 in. thick and for tensile strengths of 25,000 to 48,000 lbs. per sq. in. to secure density, hardness, strength, rigidity, toughness, machinability, wear resistance and reduction of chill, by means of nickel and nickel chromium alloys are given in a 4-p. folder, the first of a series of data sheets issued by International Nickel Co., 67 Wall St., New York. N. Y.

THE STREAM OF EXPERIENCE is the title of a booklet issued by the Fuel Engineering Co. of New York commemorating its twenty-fifth anniversary. How selection of fuel for steam generation has been developed into a science is briefly related and short biographical sketches of the personnel of the company are included.

SELF-SYN Motor Bulletin No. 540 of the Ideal Electric & Manufacturing Co., Mansfield, Ohio, is now available giving description of the motor, details of the design, construction and characteristics with illustrations, diagrams, and characteristic curves.

BULLETIN No. 175, issued by Foxboro Co. of Foxboro, Mass., describes the theory and operation of the Stabilog system of automatic control. Separate sections are devoted to descriptions of the application of the system to temperature, pressure, liquid level and flow control.

WALDRON Silent Steel Gears, made of laminations coated with grahite are described in Bulletin No. 71 of the John Waldron Corp., New Brunswick, N. J. Dimension tables for gears 2¼ to 15½ in. outside diameter are given, relations of diametral pitch and horsepower capacity for various sizes, with directions for selecting sizes, for machinery, and price list.

CONSTRUCTION and advantages of Vim Tred leather belting are set forth in a 16-p. booklet issued by E. F. Houghton & Co., 240 W. Somerset St., Philadelphia, Pa.

REDLER CONVEYORS for grain, coal and other bulk materials, to work vertically, horizontally, inclined or around curves are described in a 20-p. catalog issued by Stephens-Adamson Mfg. Co., Aurora, Ill.

MODERN ENGINEERING Data on Leather Belt Drives is the title of a 32 page, paper bound, 9 by 12 volume, published by Alexander Bros., Inc., Philadelphia, Pa. This booklet is a complete treatise on leather belt drives, showing how to design belt drives, and giving miscellaneous information on standard motor drives, pulley diameters, horsepower ratings and belt speeds.

YARWAY CYLINDER-GUIDED expansion joints with the Gun-Pakt feature are illustrated and described, with dimension tables given, in a 16-p. catalog, bulletin EJ-1904 of the Yarnall-Waring Co., Mermaid St., Philadelphia, Pa.

SARCO CO., INC., 183 Madison Ave., New York, N. Y., is sending out a 12-p. catalog of the Sarco temperature regulator for heat control in industry.

SYSTEMS OF WATER TREATMENT and their respective fields of use are discussed in a booklet on zeolite softeners distributed by the Cochrane Corporation, Philadelphia. The chemistry of softening is set forth, followed by a description of zeolite softener apparatus, an explanation of methods of rating zeolite softeners, and a discussion of single unit vs. double unit softeners and their respective advantages and fields of use.

NELSON E. CHANCE, formerly district manager of the Houston office of The Brown Instrument Co., has been appointed assistant sales manager with headquarters at Philadelphia.

THE LOUIS ALLIS CO., of Milwaukee, Wis., in its Bulletin 512, describes the splash-proof motor recently placed on the market. Splashing liquids in the neighborhood of the motor are prevented from entering the motor windings through the ventilating air passages by means of a double baffle in an elliptical-shaped air passage in each end bell.

AUTOMATIC Speed Control as accomplished by its variable speed transmission is described and illustrated in an 18-p. bulletin, T5645, issued by Reeves Pulley Co., Columbus, Ind.

DESIGNED TO interest every engineer and plant executive who has a bearing problem, an 18 page booklet on "Cutless Rubber Guide Bearings as Applied to Hydraulic Turbines" has just been published by The B. F. Goodrich Rubber Company, Akron, Ohio. It was written by R. E. B. Sharp, hydraulic engineer, Baldwin-Southwark Corporation, I. P. Morris division, Philadelphia, Pa., and presents material that should be valuable to anyone making a study of bearing problems in any field. There are now 42 hydraulic turbines with Cutless rubber bearings in operation, with an aggregate capacity of 514,010 hp.

DARCOID CO., 179 Christopher St., New York City, has issued a new catalog of its packings with service application data.

NEW GENERAL CATALOG of the Foster Wheeler Corpn., 165 Broadway, New York, N. Y., is made up in loose leaf form to permit ready revision of any section. It covers steam generators, water walls, superheaters, economizers, air heaters, water-sealed ash dischargers, condensers, centrifugal and steam jet pumps, heaters and evaporators, expansion joints, cooling towers and vacuum refrigeration. Sections on pulverizers, feeders and burners, heat exchangers and industrial heaters will soon be ready.

THE B. F. GOODRICH RUBBER CO., Akron, Ohio, has just issued a new eight page supplement to its mechanical goods catalog on its "Highflex Transmission Belt," which discusses function and varied operating conditions of transmission belting, some of the complexities involved in making rubber belts, discussion of rubber compounds and construction used in Highflex and flexibility.

BYERS GENUINE WROUGHT IRON BILLETS is the title of a bulletin telling something of the latest addition to the line of products manufactured by A. M. Byers Co., Pittsburgh, Pa.

SYMPOSIUM on Steel Castings is a 254 page, paper bound volume, published jointly by the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa., and the American Foundrymen's Association, 222 W. Adams St., Chicago, Ill. The publication comprises ten papers on steel castings as presented at the Atlantic City meeting last June, the purpose being to provide the engineering profession with authoritative information on the properties of carbon-steel and alloy-steel castings. A considerable portion of the material is devoted to corrosion resistance steels covering the physical properties at room and elevated temperatures, welding behavior, coefficient of thermal expansion, melting point and maximum temperature for safe use. Extensive oral and written discussion adds to the value of the papers presenting a broader view of the subjects. Price of the volume is $1.00 and copies can be obtained from either of the societies mentioned above.

Power Plant Construction News

Ala., Montgomery—Montgomery Utilities Corporation is considering construction of a one-story cold storage and refrigerating plant. Cost reported over $25,000, with equipment. T. B. Peabody is general manager.

Ala., Sulligent—Common Council plans installation of a pumping plant in connection with new municipal water system. Entire project will cost about $40,000. R. L. Totten, Homeward Station, Birmingham, Ala., is consulting engineer.

Ark., Paragould—At a special election, bonds for $100,000 have been authorized for a municipal electric light and power plant, and plans will be completed at early date by City Council. W. A. Fuller Co., 2916 Shenandoah Avenue, St. Louis, Mo., is consulting engineer.

Calif., Brawley—City Council is considering construction of a municipal electric light and power plant, using Diesel engine-generating units. Estimates of cost, totaling about $200,000, have been made by Burns-McDonnell-Smith Engineering Corporation, 1031 South Broadway, Los Angeles, consulting engineer.

Calif., Los Angeles—Bureau of Power & Light, 207 South Broadway, has plans nearing completion for new one-story power substation, 50x130 ft., in Palms district, estimated to cost about $150,000, of which more than one-half will be expended for equipment. Engineering department is in charge.

Calif., Oakland—Maury I. Diggs, 364 Fourteenth Street, Oakland, architect, has plans under way for new local brewing plant for company whose name is temporarily withheld, to include installation of electric power equipment, refrigerating plant, boiler house and other mechanical departments. Cost over $500,000. Similar plant is planned by same company at Los Angeles, Calif., to cost close to like amount.

Calif., San Bernardino—Arrowhead Brewing Co., Los Angeles, care of A. C. Zimmerman, 824 H. W. Hellman Building, Los Angeles, architect, plans installation of electric power equipment, refrigerating machinery and other mechanical equipment in new brewing plant at Mill and E Streets, San Bernardino. Cost about $100,000. Richard R. Nelson is president.

Calif., San Diego—Bureau of Yards and Docks, Navy Department, Washington, D. C., is asking bids until March 8 for three 500-hp. watertube boilers, including oil-burning units, soot blowers, boiler feed pumps, deaerating feed water heater, boiler accessories, piping, etc., for power house at naval operating base, San Diego, as per Specification 7171.

Colo., Golden—Golden-Denver Metropolitan Mutual Water Association, care of Douglass & Thwaits, Wilda Building, Denver, consulting engineers, plans installation of pumping plants, elevated steel tanks and towers, pipe lines and other mechanical equipment for water system for service at Golden, Arvada and other points in Jefferson County. Entire project reported to cost over $2,000,000. Ralph I. Meeker, 1669 Broadway, Denver, consulting engineer, is also identified with project.

Fla., Crystal City—American Potash & Super-Phosphate Corporation, Canal Bank Building, L. M. Turnbull, vice-president and general manager, recently organized, plans installation of electric power equipmet and steam power plant at proposed potash and commercial fertilizer plant at Crystal City. Initial unit will cost over $400,000.

Ind., Evansville—Weil Packing Co., 1700 Oakley Avenue, is having plans prepared for new one-story cold storage and refrigerating plant at meat-packing works. Cost close to $40,000, with equipment. H. Peter Henschien, 59 East Van Buren Street, Chicago, Ill., is engineer.

Ind., Madison—City Council plans installation of pumping machinery and auxiliary mechanical equipment in proposed new municipal water plant. John W. Moore, Knights of Pythias Building, Indianapolis, Ind., consulting engineer, will make surveys. Estimated cost over $50,000.

Iowa, Rockford—Common Council is arranging a fund of $105,000 for construction of a municipal electric light and power plant, and will have plans prepared in near future.

Kan., Burlington—Common Council is considering a report secured from E. T. Archer & Co., New England Building, Kansas City, Mo., consulting engineers, for construction of municipal electric light and power plant to cost $85,000, with equipment, and distributing system to cost about $33,000, and will make early decision on project. Expected to ask bids soon.

Md., Crownsville—Crownsville State Hospital has plans nearing completion for extensions and improvements in steam power plant at institution, including installation of boilers, pumps and other mechanical equipment. R. P. Winterode is superintendent.

Mass., Boston—Board of Trustees, City Hospital, 818 Harrison Avenue, is considering installation of a Diesel engine-generating plant for service at institution. Estimated cost about $25,000. Elliot Earl, consulting engineer for municipal light committee of City Council, will prepare specifications and ask bids.

Minn., Albert Lea—City Council has engaged Black & Veatch, 405 East Thirteenth Street, Kansas City, Mo., consulting engineers, to make surveys and estimates of cost for a municipal electric light and power plant and system.

Miss., Starkville—Common Council is planning installation of a municipal power station, using Diesel gas engine units as prime movers, and local distributing system. Program is estimated to cost about $100,000, and financing in that amount is now being arranged.

Mo., Clayton—Light Committee of City Council, F. A. Cammann, chairman, has preliminary surveys under way for a proposed municipal electric light and power plant. Estimated cost over $200,000. Russell & Axon, Roosevelt Building, St. Louis, Mo., are consulting engineers.

Mo., St. Charles—City Council is arranging a fund of $300,000 for construction of a municipal electric light and power plant. Plans are being drawn by Russell & Axon, Roosevelt Building, St. Louis, Mo., consulting engineers.

N. J., Harrison—National Oil Products Co., Essex Street, plans installation of electric power equipment in proposed new four-story plant addition. Estimated cost about $175,000. Henry D. Scudder, Jr., 9 Clinton Street, Newark, N. J., is architect and engineer.

N. Y., Long Island City—Allied Brewing Corporation, 25 Broadway, New York, recently organized, plans installation of electric power equipment, refrigerating machinery, tanks and other mechanical equipment in new brewing plant at 43-64 Vernon Boulevard, Long Island City, where site has been secured. Boiler plant is also planned. Entire project reported to cost over $1,000,000.

N. Y., Olean—Board of Aldermen is considering construction of a municipal electric light and power plant. Estimates of cost will soon be made. Daniel N. Kane, alderman, is active in project.

Ohio, Bellefontaine—City Council is planning extension and improvements in municipal electric light and power plant, including installation of turbo-generator unit and auxiliary equipment. F. M. Baxley is chief engineer, in charge.

Ohio, Dover—Department of Public Service, C. H. Krantz, director, is considering extensions and improvements in municipal electric light and power plant, including installation of additional equipment. Waldo Hartline is engineer.

Okla., Holdenville—Crosby-Moran Co., Exchange Bank Building, Tulsa, Okla., plans installation of air compressors and other power equipment, tanks, etc., in new gasoline refining plant near Holdenville. Entire project will cost over $125,000.

Pa., Pittsburgh—Neville Co., Neville Island, plans installation of power equipment, tanks and other mechanical equipment in connection with rebuilding of portion of coal byproducts plant, recently destroyed by fire. Loss about $70,000.

S. C., Abbeville—Abbeville Power Co., care of J. Roy Pennell, 134 Pine Street, Spartanburg, S. C., recently formed by Mr. Pennell and associates, has secured permission from State to construct and operate new hydroelectric generating plant on Rocky River, referred to in these columns last month, and plans will soon be drawn. Transmission line will be constructed from power site, near Lownesville, to Abbeville and vicinity, about 17 miles. Entire project will cost about $175,000.

Va., Luray—City Council is considering construction of a municipal electric light and power plant, estimated to cost close to $100,000, with equipment and power lines. Types of equipment to be used will be investigated at once.

Wash., Spokane—Spokane Gas & Fuel Co., Spokane, James L. Stone, vice-president and general manager, plans installation of series of air compressor plants, distributing stations, meter houses, pipe lines and other structures for natural gas service in connection with proposed steel pipe line from Cut Bank, Mont., gas fields to Spokane and vicinity, about 300 miles. Entire cost close to $10,000,000.